Journal of the Society of Arts.

FRIDAY, JANUARY 11, 1856.

NOTICE TO INSTITUTIONS.

A meeting of representatives from Institutions in the neighbourhood, or within easy access of London, has been fixed to be held at the Society's House, John-street, Adelphi, on Friday, the 18th of January instant, at 6 P.M., to confer with the Council on the best means to be adopted for practically giving effect to the Society's scheme for the examination of members of classes, for the promoting of the formation of classes, and to discuss whether any or what steps are desirable to be taken in reference to lectures. In inviting to this meeting a section only of the Institutions, the Council has had in view simply their convenience, and with no desire to exclude any; on the contrary, the Council will be glad to have the attendance of representives from any Institution in Union, whether near or distant.

The Institutions proposing to send representatives to this meeting, are requested to forward to the Secretary of the Society of Arts, a few days previous to the meeting, the names of those who will attend on their behalf. It is to be understood that this meeting is not to be considered as a formal conference, but simply in the light of a committee meeting.

EXTRA-ORDINARY MEETING.

Wednesday, January 9, 1855.

An Extraordinary Meeting was held on Wednesday evening, the 9th inst., Joseph Glynn, Esq., F.R.S., in the chair, for the purpose of receiving and discussing the following paper:—

THE PRESENT POSITION OF THE IRON INDUSTRY OF GREAT BRITAIN, WITH REFERENCE TO THAT OF OTHER COUNTRIES.

SECOND AND CONCLUDING PART.

By J. Kenyon Blackwell, F.G.S.

The ores of iron must be separated from the carbonic acid or water with which they are associated before their reduction can be effected. This separation is produced by calcination, either in the open air or in the chamber or furnace in which reduction takes place, but, whatever the original state of the ores may have been, in examining the nature of the re-actions which produce their reduction, they must be regarded at the period immediately preceding it, as oxides, either mixed with various substances as impurities, or, perhaps, as the temperature to which they are subjected is increased and deoxidation proceeds, entering into chemical combination as silicates before perfect reduction is completed.

In all processes employed in the manufacture of iron, the re-agent by which the reduction of the ore is effected is carbon. It is essential in all chemical re-actions that there should be intimate contact of those bodies between which this reaction takes place. One at least of any two solid bodies entering into this relation must therefore be brought in the first instance into the liquid or gaseous state. Between two solids the number of points of contact is, under any circumstances, infinitely small, but it is otherwise when one of the bodies concerned is in a liquid or gaseous state. The researches which have been made into the nature of the gases of the blast furnace, have proved, what might have been predicated from theory, namely, that carbon in its gaseous state, as oxide of carbon, is the reducing agent by which the ores of iron are brought into the metallic condition.

The processes of reduction by carbon of the metallic oxides may be divided into two classes, in both of which however the oxide of carbon is the immediate re-agent. These two classes of procedure, in which the oxide of carbon is obtained in two different modes, are those of cementation and the blast furnace; using the latter term in its correct signification as embracing all those furnaces in which a current of air entering the furnace under pressure and passing through the materials contained in it is employed.

The first class of procedure, that of cementation, is characterised by the following conditions, namely, the oxygen necessary for the production of the oxide of carbon is essentially furnished by the metallic oxide to be reduced, and the heat necessary for this reduction is produced without the vessel or chamber in which the cementation is effected, and independently of the chemical re-actions which produce the oxide of carbon.

In the second class, that of the blast furnace, the oxygen necessary for the formation of the oxide of carbon is supplied by a current of atmospheric air, and the heat required in the process is developed in the furnace itself, by the re-actions necessary to produce the oxide of carbon which forms the reducing agent.

It will, therefore, be observed, that the blast furnace is essentially by its nature, at the same time both more simple and more energetic in its operations than any method for reducing ores by cementation can be. The heat required in the reduction of the ore is developed in the chamber itself in which the reduction is effected, by the mutual action of the re-agents employed, instead of being produced externally, and, therefore, at a great disadvantage. In the blast furnace, the addition of a flux to the ores treated permits the elimination of the impurities present, which cannot be effected in cementation except in those cases in which the metal itself is volatilized.

Cementation is, therefore, a process of reduction applicable to those metals only, the oxides of which part with oxygen and become fluid at a low temperature, and are themselves volatilized by a small accession of heat.

In the treatment of ores of iron, which retain the oxygen with which they are combined with strong affinity, even at the highest temperatures, except in the presence of a powerful re-agent, and which in the metallic state acquires only in the peculiar condition of carburet, sufficient fluidity to permit its complete separation from the earthy matters with which this metal is associated to a greater or less extent in all its ores, the blast furnace must always continue to retain the position which it now occupies as the only practicable method of reduction.

The term *blast furnace*, in its correct meaning, properly includes all furnaces in which the reduction of metallic oxides by the oxide of carbon is effected through the re-actions produced at an elevated temperature by the agency of a current of air forced under pressure into the mass of ore, flux, and fuel subjected to its action.

These furnaces, therefore, must be subdivided into two classes; the type of one will be found in the low and open Catalan hearth; of the other in the high and closed blast furnace, now in general use for smelting. Conformably to the somewhat erroneous practice in this country, the latter class of furnaces is that which will be spoken of in this paper as the blast furnace.

The reduction of the ores of iron in the Catalan hearth, and in other furnaces which are modifications of that class, is necessarily imperfect. A part only of the oxides introduced into the furnace are reduced to the metallic state, while another large part is lost in the formation of silicates of iron for the purpose of carrying off in fusible slags the various impurities contained in the ores.

In the elevated blast furnaces now generally used for smelting, the oxide of carbon formed in the lower part of the furnace is continually renewed after its successive re-actions, from being propelled through the superincumbent incandescent carbon by the current of atmospheric air continually entering the furnace through the tuyeres. By this continually renewed action, the whole of the oxides of iron subjected to its influence may be entirely deoxidised, and finally, by the carburising action exerted in the lower regions of the furnace, reduced to a fluid state, while the earthy matters contained in the ores pass off in vitreous slags, separated by their different specific gravity.

The current of atmospheric air forced into the lower part of the blast furnace, carries with it in its transit almost the entire quantity of the carbon introduced, the oxygen of the ores, the carbonic acid of the limestone, when used uncalcined, and, lastly, the water present, either accidentally or in a combined state, in the coal, cokes, charcoal, or minerals.

At a short distance above the tuyeres the oxygen of the air is completely transformed into carbonic acid. At a somewhat higher point this carbonic acid is reduced into carbonic oxide by the acquisition of a further quantity of carbon. From this place the nature of the gaseous current in the blast furnace is not found to vary in its character for a considerable distance upwards, the presence of incandescent carbon in excess converting instantaneously into carbonic oxide, the oxygen abstracted by the ascending current from the descending reduced oxides.

Above this point, which in furnaces of the usual form appears to be near the top of the boshes or widest part of the furnace, the deoxidation of the ore continues rapidly. Notwithstanding the greater width of the furnace, the consequent diffusion of the gaseous current, and its slower rate of ascent through the materials from this point, it exhibits rapid modifications in its character in its progress upwards. The abstraction of oxygen from the ores continues, and the transformation of carbonic oxide into carbonic acid, which is the result, remaining from this point in part unreduced, on account of the decreasing temperature of the furnace, the proportion of carbonic acid continues rapidly to augment. At some distance below the mouth of the furnace the volume of this gas becomes again stationary, the deoxidising re-actions having ceased. The only increase which it receives in this part of the furnace is from the carbonic acid of the uncalcined limestone.

The hydrogen gas found in small quantities in the lower regions of the blast furnace results from the water contained in the air introduced. Its quantity is found to continue uniformly augmenting during the ascent of the gaseous column upwards throughout the furnace, from the hydrogen still retained in the fuel, and also from the decomposition of the water which remains both in the minerals and fuel. In the upper part of the furnace some water from these sources is found to be present as steam.

It would appear, from the slow but constant augmentation of the hydrogen forming part of the gaseous current, throughout its ascent in the blast furnace, whilst water as vapour only exists within a short distance below the level of the mouth, that this gas exerts no influence as a deoxidising agent. The reduction of the ores results, therefore, solely from the ascending column of carbonic oxide.

The nitrogen contained in this atmosphere of heated gases not being capable of exerting any species of re-action on the materials of the blast furnace, remains unchanged and constant in its quantity, from the tuyeres to its exit at the mouth of the furnace. The quantity in which it is present in the ascending gaseous column at any given point, therefore, becomes a convenient datum for reference, by which the changes in the other variable constituents can be determined, and the nature of the re-actions which they indicate ascertained.

The knowledge of the changes which take place in the interior of the blast furnace, and, approximatively, of the limits within which those changes occur, enables us to determine with considerable accuracy the most suitable outline to be given internally to furnaces of this description.

The internal form of these furnaces commonly adopted, consists essentially of two frustrums of cones meeting each other at their bases, at the point where the widest part of the furnace, forming what is technically called the top of the boshes, is situated. From this point the furnace gradually contracts both upwards to its mouth, and downwards to the level of the tuyeres below. The hearth, properly speaking, is that part of the furnace only which receives the fluid metal and cinder as they fall below the level of the tuyeres. It forms a short prolongation from that point of the lower inverted cone.

The diameter of the furnace in its widest part above the boshes ought to bear a fixed relation to the diameter of the hearth at the tuyeres, the total height of the furnace, and the volume of blast which is to be introduced. The height of the furnace depends on the nature of the materials to be smelted. The ordinary practice has been to give furnaces dimensions in this part totally out of proportion to the size of the hearth. That part of the furnace where the greatest width occurs, ought to be situated higher, relatively to the total height of the furnace, than it is usually placed. From this point the interior ought to contract downwards (not suddenly, nor in any one place at a greater angle of inclination than at another), to the level of the tuyeres, the diminution in size being exactly in proportion to the gradually decreasing bulk of the descending materials, in the ratio of their reduction in volume, from the absorption of the carbon by the ascending blast, and the descent into the hearth of the liquified ores and flux.

As the reduction in volume of the materials in the blast furnace is everywhere gradual, from the point where the carbon with which they are interstratified commences to be volatilised, and the ores commence to fuse and unite with the limestone, it is evident that the diminution in the sectional area of the blast furnace from its widest part downward toward the tuyeres ought to be equally gradual, and in the same ratio. When any departure from this rule occurs, by lowering and flattening the boshes, and by prolonging the narrow dimensions of the hearth above the tuyeres, it is evident that all those materials which are situated near the outer part of the furnaces must be arrested in their descent, and that the central portion will have a tendency to subside more rapidly than the exterior, whereas, when the sectional area of the blast furnace is contracted only in the ratio of the diminution in volume of the descending materials, the whole of the burden of the furnace must subside uniformly, without any one portion of it out-running the other.

If that part of the blast furnace commencing at the point where it attains its greatest width, were continued of the same wide dimensions upwards to its mouth, two objectionable results would ensue; first, the upper part of the furnace would be cooled by the too rapid dispersion of the ascending column of heated gases, and by the entire absence of the reverberating effect of the contracted mouth; and secondly, the materials could not be equally spread from the filling holes over so wide a surface. The diameter of the upper part of the furnace ought, therefore, to be such as will cause the materials thrown in at the filling-holes to distribute themselves equally in their descent over every part of the sectional area of the furnace, and will produce such a reverberation only of heat as shall be sufficient to expel the water and carbonic acid contained in the ma-

terials, without consuming any of the carbon of the fuel; this ought to remain intact until it reaches the lower regions of the furnace, where it is vaporised as carbonic oxide, and produces the re-actions on which the reduction of the ore depends.

It is, therefore, evident that the dimensions of the mouth of the blast furnace ought to be sufficiently large to prevent the waste of fuel which may be produced from the reverberating effect of a narrow top, whilst they are sufficiently contracted to prevent a too rapid dispersion of the heated gases; at the same time, the filling apertures which surround the mouth ought to be in such positions, relatively to the mass of materials contained in the furnace below, as to produce an equable distribution of those materials by spreading them, as they fall, both towards the outside and towards the centre of the furnace. It has been found in practice that a diameter of the mouth of the blast furnace somewhat greater than half of its largest dimensions above the boshes is such as accomplishes both these objects.

Below the level of the filling apertures the sectional area of the blast furnace should regularly enlarge, increasing somewhat rapidly to its widest diameter. This, as already observed, ought to be at that point where the reducing re-actions of the blast furnace commence. The full width of the furnace ought to be prolonged downward to some distance below this limit, because the re-actions of the furnace at their commencement, before the fusion of the ore and limestone takes place, produce little change in the volume of the materials subjected to their action; and it is desirable that the materials should be spread over a wide sectional area, through which they will descend slowly, exposed to the deoxidising current of ascending gases, according to their different specific gravities or state of solidity or fluidity.

The proposition laid down by some of the principal writers on the theory of the blast furnace, namely, that the materials in it, which possess very different specific gravities, descend through the furnace in the same distinct strata as those in which they are spread when introduced at the mouth, is entirely erroneous. Their descent is in vertical lines, moving parallel to each other at different rates, according to their different specific gravities; and this species of motion produces a perfect intermingling of the whole. The internal outline of the furnace ought to be such as not to interrupt this motion in any part of the descending column, nor by a too rapid contraction of the sectional area of the furnace to arrest the outward portions of the materials, while the internal portions, situated vertically above the hearth, leave the others behind in their passage downwards.

It is, therefore, evident that the point where the diminution in the sectional area of the blast furnace commences downwards, below that where its greatest dimensions have been attained, ought to be that where the volatilisation of carbon commences; and that the blast furnace ought to diminish in sectional area in the exact proportion that the carbon of the burden decreases in volume, increasing as the liquefaction of the ores and flux, and the rapid descent of this part of the materials into the hearth, causes an increasing diminution in the bulk of the descending materials.

Other circumstances being equal, the sectional area of the blast furnace hearth at the level of the tuyeres forms the measure of the amount of blast which will enter the furnace, and this again determines its smelting power. The only necessary limit to the size of the blast furnace hearth will be found in the power of the blast to penetrate equally the materials with which the hearth is filled, from the tuyeres externally, to its centre.

The height of the blast furnace depends on the length of the transit downwards exposed to the reducing atmosphere of the ascending current of gases which is necessary to produce the perfect reduction of the ores smelted. With refractory ores the body of the furnace above the tuyeres ought to be higher and narrower, than when easily-reducible ores are used, the dimensions of the hearth itself remaining in each case the same.

In furnaces blown with heated air, the re-action of the oxygen of the blast on the carbon contained in the furnace is much more rapid than when cold air is used. In cold-air furnaces, there is a zone of considerable height in proximity to the tuyeres in which an oxidising and decarbonising action is exerted by the blast. In the hot blast furnace the height of this zone is greatly diminished. Practically it seems to disappear.

From the more rapid re-action of heated than of cold air on the carbon contained in the blast furnace, the temperature of the lower part of hot-blast furnaces is greatly augmented; at the same time, the reducing gases required to deoxidise the descending minerals are produced in greater volume at a lower level in the furnace. From these causes the height of furnaces blown with hot air is not necessarily so great as that of those in which cold air is used.

The reduction of the minerals in the blast furnace takes place by the action of the blast proceeding from the circumference of the furnace towards the centre. The ascending current of reducing gases impelled by the blast, but met by the counteracting pressure of the descending materials, finds the easiest channel for its ascent near the exterior of the furnace, at the same time that its velocity forces it towards the centre. It is desirable that the dimensions of the furnace should be such as to produce the equal diffusion of these gases through the whole body of desending materials.

The analyses which have been made of the gases of the blast furnace, show that only about one-third in volume of the oxide of carbon produced in the blast furnace is utilised before its escape at the mouth.

It has already been observed, that before the reduction of the ores smelted in the blast furnace can take place, the water and carbonic acid which they contain must be expelled. This must be effected either by calcination in the open air, previous to their introduction into the furnace, or in the furnace itself. When this calcination takes place in the blast furnace, it must result in a considerable diminution of the heat of the furnace; but since, along with the escaping uninflamed gases, there is also a large amount of surplus heat in the gaseous current, this may be, to a certain extent, utilised for their calcination, without any apparent loss of fuel in the furnace. This practice of calcination in the furnace, even to a limited extent, can, however, only be admissible when the waste gases are not utilised by combustion for other purposes.

The preliminary calcination of the limestone employed as flux in smelting before its introduction into the blast furnace would, undoubtedly, produce some economy in fuel.

The fuel employed in the reduction of ores in the blast furnace possesses this reducing power only in respect of, and in proportion to, the carbon which it contains. Whether, therefore, it be wood or coal, the question regarding its employment in the raw state, or partially or wholly carbonised, rests solely on the circumstance whether it can be more perfectly and economically carbonised in the open air, in closed ovens, or in the blast furnace itself.

The differences in the chemical nature of the various elements, forming on the one hand vegetable, and on the other mineral fuel, are only in degree, and not in kind, except in so far as regards the composition of the earthy residuum of ashes left after the volatilization of the other elements. It may, therefore, be in the different nature of the substances present in the ashes of wood and of coal that we must seek for the explanation of the causes which produce such a widely different quality in iron smelted with these two species of fuel. Sufficient attention has not hitherto been paid to the ascertaining of the exact nature of the diversities in the composition of this portion of the constituents of wood and coal, and of different varities of coal.

The mechanical operations by which a large part of the earthy impurities of all coal seams of a caking nature

might be separated from them before they are converted into coke, have been hitherto generally neglected in this country.

Abstraction being made of these variable constituents (a large part of which are only present in coal as impurities), no distinct line of demarcation, founded on the chemical nature of the two bodies, can be drawn between wood on the one hand and coal on the other. Both are composed essentially of carbon, hydrogen, oxygen, and nitrogen. Oxygen is present in the largest quantity in wood, while its proportion is lowest in the most highly mineralised, or anthracite coal.

The whole of the combustible bodies of this nature range themselves in one general series, the different classes of which may be divided into the following seven species, in accordance both with the physical characters which they exhibit, and at the same time their greater or less degree of oxygenisation; namely, wood; lignite; cannel, or splint coal; non-caking coal, yielding a long flame; caking coal; non-caking coal, yielding a short flame; and lastly, anthracite.

It has already been observed, that the fuel employed in the blast furnace possesses a reducing power only in proportion to the quantity of carbon which it contains, and that the question whether this fuel ought to be used in its raw state or carbonised, and whether the coke or charcoal into which it must be converted should be prepared in open fires or in close ovens, depends solely on the quantity and quality of the coke or charcoal which will be obtained from it, by these various systems, and the comparative economy with which they can be prepared.

Those species of coal which it has been found most easy to employ in the blast furnace have been the non-caking varieties. Caking coals require to be mixed with coke to a greater or less extent, to prevent the adhesion of the whole of the fuel in one mass.

Notwithstanding the great extent to which raw coal and partially torrified wood have been long used in the blast furnace, both in this country and abroad, it certainly appears, on a careful consideration of the nature of the process to which both coal and wood must be subjected, either within or out of the blast furnace, before the carbon which they contain can be utilised in the reactions of the furnace, that their carbonisation may be effected with most economy, and that the quality of the charcoal or coke which results from this process will be best, when effected in closed ovens, prior to the introduction of the fuel into the blast furnace, and not within the furnace itself.

When wood or coal are coked at a low temperature, the hydro-carbon products, which carry off a large quantity of carbon, are formed much more abundantly than when this operation is conducted at a high temperature. Under the influence of high temperature, the hydrogen of these substances passes off either alone or in its proto-carbonated state. If wood or coal are coked in closed ovens, the degree of heat to which they are subjected in that process, and its duration, which is necessary to harden the product, can be controlled. When this operation takes place in open fires, or in the blast furnace itself, these two conditions cannot be regulated with the same facility, nor can the supply of oxygen to the incandescent carbon be determined with the necessary exactitude to limit its supply simply to that necessary to obtain the requisite temperature. The form adopted in the construction of the coking oven is an important element in obtaining the requisite temperature.

Coal and wood not only give the highest yield in coke and charcoal, when their carbonisation is conducted at an elevated temperature, but they are found to be superior in quality, and better fitted for use in the blast furnace, when they have been subjected for a considerable time to the action of this elevated temperature than when they have been coked rapidly at a low heat. It is, moreover, important that the temperature to which they are subjected should be raised to its highest point as soon as possible after the carbonisation commences. These necessary conditions can only be obtained by coking in close ovens.

The system of coking in close ovens possesses another advantage, in permitting the utilisation of the heat afforded by the combustion of the waste gases of the coal, in the raising of steam. Many of the largest continental works derive the whole of their supply of steam from boilers set over their coke ovens.

The separation of the iron in a metallic state from the earthy matters and impurities contained in its ores is effected most perfectly in the blast furnace when the heat of the furnace is sufficient to produce at least a medium degree of carburation in the iron, and when there is a sufficient amount of lime present as flux to produce a fluid cinder. White or imperfectly carburised iron usually contains the whole of the sulphurets of the ores, and probably variable quantities of unreduced oxide, and of the earthy matters contained in the ores, mechanically mixed with it; at the same time the heat of the furnace not being sufficient to effect a perfect reduction of the ore a large quantity of oxide passes into the slag in the state of silicate. In this country, in South Wales especially, very large losses are constantly sustained by the ironmasters by this imperfect smelting.

The oxide of manganese, found in larger or smaller quantities in almost all ores of iron, is to a great extent reduced in the blast furnace, and passes into the pig iron. It is partially or wholly removed by oxidation in the subsequent processes of the refining and puddling furnaces.

An elevated temperature in the blast furnace has a tendency to reduce a portion of the silica contained in the ores to a metallic state, when it enters as an alloy into the crude iron. The same cause appears to act to a minor degree in producing to a small extent the reduction and alloy of other bodies present in the furnace; but silicium and other metals of this class are entirely, or in great part, eliminated in the subsequent oxidising processes of the refining and puddling furnaces.

The sulphurets of iron contained in the ores of that metal, and often, even more largely, in the mineral fuel used in its reduction, are partially, but not wholly, decomposed in the blast furnace. An elevated temperature and the presence of lime aid this decomposition, and the elimination of the sulphur as sulphuret of calcium.

The phosphate of iron contained in these ores is reduced to the state of phosphuret in the blast furnace, and passes entirely into the pig-iron. This substance has been found, but only rarely, in furnace slags as phosphate of alumina; it may possibly have existed in that combination in the ore previous to smelting. The phosphuret of iron which is reduced in the blast furnace is again subjected to oxidation in the refining and puddling furnaces. It passes partially or wholly into the slags, which are separated in those processes.

Much controversy has taken place with respect to the difference in quality supposed to exist between pig-iron smelted with cold and with hot blast. While no doubt could exist with respect to the economy of fuel, the greater regularity in the action of the blast furnace, and the larger quantities of metal obtained under equal circumstances by the use of the hot blast, it has generally been considered that the pig-iron smelted with hot was inferior in quality to that produced with cold air. Undoubtedly, this opinion has been created to a great extent from ignorance of the facts of the case. Furnaces blown with heated air exert greater reductive power than those in which a cold blast is used. This has led, since the introduction of hot blast, to the extensive usage in iron smelting of refractory ores not formerly smelted, a large part of which have been ores of a class calculated to produce inferior iron; and it is from the use of ores of this nature, far more than from any deterioration in quality arising from the use of a heated blast, that this opinion has originated.

At the same time it appears to have been proved that the more elevated temperature of the hot blast furnace has a tendency in a slight degree to increase the quantity of silicium and other cognate metals which form alloys with pig-iron in the smelting process. Phosphuret of iron is said to have been found to a minutely increased extent in combination with pig-iron smelted by hot air when compared with that obtained from the same minerals by cold blast. On the other hand the sulphurets of iron appear to be removed to a greater extent by the agency of hot air. The subsequent oxidising processes in the conversion of pig into wrought iron eliminate in part, or wholly, these foreign metals as oxides, and the phosphuret of iron as phosphate, in the slags produced.

The essential nature of the process of reduction in the blast furnace, by a deoxidising gaseous current, in which the deoxidising agent, carbonic oxide, must be present constantly in excess, is such, that this inflammable gas must always be discharged in considerable quantities from the mouth of the blast furnace. These waste gases of the blast furnace, which always contain hydrogen also, to a certain extent, must be capable of developing heat largely after their discharge from the blast furnace by a more perfect combustion. In those places where fuel is expensive, or where the coal used for other purposes is of a caking nature, and could be utilised as coke in the blast furnace, it has been found productive of economy to collect and employ these gases for raising steam for heating the blast, for puddling, and for re-heating iron. In the last two cases, in which an elevated temperature together with a perfect command of the operation is required, a heated blast is employed to produce complete and regular combustion of the waste gases.

To enable the waste gases of the blast furnace to be collected without injury to the working of the furnace itself, and in such a state as will permit their combustion to be effected to the most advantage, the height of the furnace must be raised, in order that these gases may be withdrawn at a point where they have finished their work, yet sufficiently far below the mouth of the furnace for them to be obtained dry, and also beneath the point where they begin to enter into combustion from contact with the atmospheric air. The full width ought to be retained in the mouth of the furnace to prevent combustion of fuel, occasioned by the excessive heat caused by reverberation, which is always destructive to the fuel when it occurs, and prejudicial to the working of the furnace whether the gases are abstracted or not. The necessary closing of the top, and the pressure required to be produced on the gases to conduct them into the channels prepared for their exit, must be effected by the materials which fill the mouth of the furnace above the apertures made for the escape of the gases.

When these conditions are fulfilled, the waste gases of the blast furnace may be rendered available as fuel for various purposes, without any injury to the working of the furnace. The plans adopted for their use in this country have been generally defective, and frequently very objectionable in their details.

The carburised crude iron obtained in the blast furnace is converted into malleable iron by one or more operations, all of which are of an oxidising character. By these it is sought to separate the carbon combined with the iron in the gaseous form as oxide of carbon, whilst the metallic bodies, forming alloys with it, and the phosphuret of iron present, are also oxidised, and pass partially or wholly into the slags.

In the Catalan fire, one of the earliest forms of the blast furnace, all the varied processes required to produce malleable iron were combined in one operation. The production of carburet of iron took place in the upper part of the hearth, (the fluidity thus acquired separating the metal from the earthy matters associated with it in the ore), and this carburet was subsequently decarburised, to a greater or less extent, in the lower part of the hearth, by the re-actions resulting from the effect of the blast, of the oxide of iron produced under its influence, and of that remaining unreduced in the slags formed. In the production of natural steel, the skill of the workman arrested this decarburising action at the necessary point.

In the modern system these operations are subdivided. The pig iron produced with charcoal, when its conversion into malleable iron is to be completed with charcoal, is decarbonised in the charcoal refinery; with or without an intervening process termed *mazéage*. Charcoal pig iron, wherever mineral fuel is accessible, is now, however, generally converted into wrought iron in the puddling furnace with coal. Pig iron produced with coke is either subjected to a preliminary decarburation in the oxidising blast hearth, termed also in this country a refinery, and the operation thus commenced is afterwards completed in the oxidising air-furnace, termed the puddling furnace; or, in recent practice, the complete decarburation of the crude iron is effected without the intervention of the refinery in the puddling furnace, by the process called boiling.

It is said that, at several works abroad, the attempt to arrest the process of decarburation in the puddling or boiling furnace at that point in which the conversion has proceeded only so far as to leave the iron in the state of steel, or subcarburet, has been successful; and that a valuable natural or puddled steel, not requiring cementation before conversion into refined or cast steel, has been the result.

All the processes employed in the conversion of crude, or carburised iron, into malleable iron, are processes of oxidation, in which the carbon is removed either by direct oxidation, or by the re-actions occasioned by the presence of oxide of iron formed or introduced during the process. The presence of oxide of iron in excess, appears necessary in all these processes to form fusible slags, consisting essentially of silicate of iron, in which the silica and other bodies, separated by oxidation from the iron, or present accidentally, are wholly or partially removed.

The question for investigation, in examining the nature of these various processes of conversion, is, therefore, whether the removal of the carbon of the crude iron, and at the same time, the elimination of the impurities contained in it, is effected with the smallest possible waste by oxidation of the iron subjected to them.

That the present systems of procedure are frequently extremely faulty, appears to be a necessary deduction from the fact, that in some of the largest iron-making districts of Great Britain, the production of one ton of wrought iron of inferior quality is only obtained by the consumption of nearly one and a-half tons of crude or pig iron.

The crude iron from which wrought iron of the best quality is produced, is that possessing a medium degree of carburation, or what is usually termed grey **pig-iron.** White iron, which possesses an inferior degree of fluidity to grey pig-iron, and which comes, as it is termed, more rapidly to nature, is that quality which is most generally employed in the manufacture of wrought iron, especially when the conversion is effected by the single operation of boiling in the puddling furnace; but this species of pig iron, being the result of imperfect re-actions in smelting, is always more impure than grey or more highly carburised pig iron obtained from the same materials, and does not produce wrought iron of the best quality.

In those countries in which the pig-iron produced is smelted with charcoal, but coal is available for conversion into malleable iron, the charcoal refinery is generally abandoned for the puddling furnace, it being found that the quality of the iron resulting from the latter process is sufficiently insured by its previous treatment in the blast furnace with charcoal.

In Great Britain, where the smelting process is almost exclusively conducted with coal or coke, it is found that nearly the same result can be obtained, with reference to the quality of the bar iron produced, by the treatment of the pig-iron thus smelted, in its final stage of conversion into wrought-iron, in the charcoal refinery with charcoal.

It is an important subject for investigation to ascertain what are the precise causes to which this amelioration of quality from the use of vegetable fuel is due, when used in the treatment of iron in processes which have no analogy to each other. The circumstances of the two cases appear to point to the possibility that the eliminative effect exercised as fluxes in both instances by the ashes of the vegetable fuel employed, may have some effect in producing this improvement in quality. Should such really be the case, we may then replace charcoal as fuel with advantage in those cases in which it is still employed, by the use of artificial fluxes producing an equivalent effect.

The coke refinery or running out fire occupies in this country, by its results, the same position with reference to the charcoal refinery as the process termed *mazéage* on the Continent. Previously to the introduction of the process termed boiling (in contradistinction to puddling), in the treatment of iron in the puddling furnace, the whole of the metal puddled was subjected in the first instance to the oxidising and decarburising process of the coke refinery. Refined metal is still used to a large extent, either alone or mixed with pig iron, in the puddling furnace in this country. It is also employed exclusively in the charcoal refinery.

The pig iron to be decarburised in the refinery is usually melted with rich silicates, and occasionally with oxides of iron, intended, as in other processes of this nature, to protect the melted iron in some degree from the oxidising effects of the blast, and to re-act on the carbon which it contains. The quantity employed depends on the degree to which the pig iron is carburised.

In the presence of silica in excess in the refinery hearth, the oxide of iron formed by the blast is not reduced by the carbon, but is lost by entering into the slags. It is, therefore, desirable to exclude it as much as possible in the operation. For this reason, the coke employed should be free from shale, and contain only a low per centage of ash. Lime in small quantities may be used advantageously in the refinery, to enter into combination with the silica present, but it can only be employed to a limited extent, as it would otherwise render the slags too thick.

It is of the utmost importance that the cokes used in this process should be as free as possible from sulphuret of iron, which they often contain largely. The greater part of this sulphuret present enters into combination with the metal and does not pass off in the slags.

Phosphuret of iron, if present in the pig iron, appears to be converted into phosphate, and enters into the slags. It is found largely in many refinery cinders which have been submitted to analysis.

The loss of iron in the refinery process is very large. It varies from 10 to 20 per cent.

The charcoal refinery in general use in those countries where mineral fuel is not accessible for the conversion of crude into malleable iron, is still employed in this country, when it is desired to produce iron of the best quality. It has already been observed that the causes of the amelioration in the quality of iron smelted and partially decarburised with coke, when the last stage of its conversion into wrought iron is effected by the agency of charcoal in the refinery fire, forms an important subject for investigation.

The charcoal pig iron treated in these fires is usually that termed white, or mottled, which is selected on account of the less degree of fluidity which those qualities possess, and the greater rapidity with which they come to nature. When grey pig iron is used, it is ordinarily decarburised, to a certain extent, by some of the processes termed *mazéage*. In this country, where iron smelted with coke is thus treated, grey pig-iron possessing a medium degree of carburation is generally employed, on account of its greater purity, as compared with white or mottled iron: but it is always converted into refined metal in the coke refinery prior to its use in the charcoal refinery.

Fluxes, strictly speaking, are not used in the charcoal refinery. They would not be advantageous unless the metal treated had been imperfectly refined in the coke refinery, the silicium of the pig iron and the silica accidentally present being removed by that process. The oxides of iron from the hammer and the subsilicates formed in the charcoal refinery during the latter part of the operation, are returned to the fire, where they in some degree protect the metal, as it subsides in the hearth, from the too long continuance of the decarburising effects of the blast, whilst they also exert on it, by re-action, a similar influence, accompanied by a reduction of a part of the oxide which they contain.

The melted and partially decarburised iron is raised, as it sinks in the refinery hearth, in order to expose it in every part to the action of the blast, and this operation is repeated on the collected mass, which is again brought to the surface of the fire, re-melted and sunk before the blast, until the whole is found to be sufficiently decarburised and refined throughout.

In estimating the precise nature of the effects produced in the charcoal refinery, it is necessary to observe that this fire, in common with all blast furnaces, contains, at the same time, at different elevations, a carburising and disoxidising, and an oxidising and decarburising zone. The imperfectly converted and imperfectly purified metal under treatment can, therefore, by a simple change of position in the fire, be re-subjected to the re-actions which take place in it, until the effects desired are perfectly accomplished.

The conversion of crude into malleable iron is now effected on the largest scale, both in this country and abroad, in the reverberatory furnace, termed a puddling furnace. The actual process followed is termed puddling or boiling, according to variations in the degree to which it is necessary to carry the re-actions of the furnace, according as partially decarburised or refined metal, or pig-iron is treated.

The term puddling is applied to that process in which refined metal, previously partially decarburised and separated from the impurities it contained in the coke refinery, is converted into malleable iron by subjecting it to the action of a current of heated air excited by the combustion of fuel in the reverberatory furnace in which the operation takes place. The boiling process is that in which pig-iron is converted by one operation into malleable iron by the more energetic re-actions induced in connection with this deoxidising current, by the more elevated temperature of the puddling furnace, and by the presence of a bath of rich subsilicates of iron.

The bottom and sides of puddling and other furnaces used in the conversion of iron ought to be constructed of cast-iron, kept cool either by currents of air, or, in those portions exposed to the greatest heat, by water, to prevent the re-action which would take place between the oxides of iron formed during these processes and the silica of a brick lining. The silica which might be introduced accidentally ought to be carefully excluded, as its presence must occasion unnecessary loss in the operation. These points are not always attended to with sufficient care.

The cast-iron bottom of the hearth is covered by a layer of scoria or silicates of iron. It is found that those slags which are the richest in oxide of iron and in which the oxides have been converted into the state of sesqui-oxide by calcination offer the greatest resistance. The cinders of the charcoal refinery are much esteemed for this purpose. When melted into one uniform mass, with the addition of oxide of iron, these scoria form a bottom, offering great resistance to the action of the melted metal.

It has already been observed that in the process of puddling, refined metal only is used, and that its conversion into malleable iron is effected solely by the re-actions induced by the current of air excited by combustion in the reverberatory furnace. This operation is effected at a lower temperature than boiling, and without the addition of the oxides and sub-silicates employed in the boiling process in conjunction with a more elevated temperature,

to produce the more energetic re-actions required in the latter.

The process of boiling is that which is now most generally used for the conversion of pig-iron into malleable iron by the agency of mineral fuel. Its nature permits it to be employed for this purpose, without the introduction of any process of decarburation similar to the coke refinery. Grey pig-iron, smelted with coke, may be converted into malleable iron by this single process, thereby avoiding the serious waste incurred by oxidation in the coke refinery, at the same time that the use of the best qualities of pig-iron without excessive waste is rendered practicable.

Grey pig-iron, of a medium degree of carburation, being the result of a more perfect state of action in the blast furnace than that by which white or mottled iron is obtained, is always more pure than iron of those classes produced from the same minerals. The length of time and amount of work which is required in the puddling furnace before grey pig-iron is sufficiently decarburised and brought to a malleable state, is also to a certain extent advantageous, in respect to the quality of the wrought iron obtained from it, because this long exposure to oxidation has the effect of more perfectly eliminating the oxidable alloys which crude iron contains.

The process of boiling, therefore, which enables pig iron of this class to be converted into malleable iron on a large scale without the intervention of any other process, and without excessive loss, possesses great value, and it becomes important to inquire whether there are any ameliorations which may be introduced into it which would enable it to be more universally adopted than it has hitherto been.

The defects in the boiling process are the following:—the wear and tear in the puddling furnace, which occurs in treating grey pig-iron, particularly that of the more fluid descriptions; the slowness of the operation; and the amount of manual labour which it entails to produce good results.

The reverberatory furnace possesses the advantage that in the conversion of crude into malleable iron, the oxidising and decarburising re-actions necessary to effect it take place without the metal itself being at the same time in contact with the fuel, and thus subjected to the waste which would be occasioned by the earthy silicates present in the mineral fuel, generally employed, entering into combination with the oxide of iron formed. In its existing form it has, however, the disadvantage that the combustion of the fuel is necessarily very imperfect, and that neither the extent of action nor the nature of the oxidising current, is sufficiently under control.

To produce perfect combustion in furnaces of the nature of the reverberatory furnace, the air entering them ought to be divided into two parts; one of these should pass through the fuel to excite combustion to volatilise the hydrogen present, and to convert the carbon of the fuel into carbonic oxide; the other portion should be air previously heated, and this air ought to enter the furnace under pressure, causing it to traverse the furnace at a different velocity to the current of inflammable gases derived from the fuel, since it is evident that fluids of nearly equal densities, travelling in the same direction at equal velocities, will not tend to mix and enter into combination in the same intimate and rapid manner as they would if the last entering current were heated, and if they were travelling respectively at different velocities.

The current of air passing through the common reverberatory puddling furnace, is not sufficiently under the control of the workman, either with respect to its volume or its nature. This class of furnaces would be greatly improved and rendered more effective in their action in the conversion of iron by such modifications as would enable the current of air which passes through them to be rendered either oxidising or deoxidising, as required. The effect of this change in the nature of the furnace would be to restrict the oxidising action to the exact extent necessary for removing the carbon of the crude iron, and for eliminating the oxidable alloys present, while excessive waste in the metal treated would be avoided.

The more perfect combustion of the fuel employed, and the necessary control over the nature of the gaseous currents within the furnace, may be obtained by restricting the amount of air admitted through the ash-pit to that required for the generation of the inflammable gases, and by the application of blast to produce their perfect combustion, and to afford, as required, the necessary excess of atmospheric air for oxidation and decarburation of the metal. The supply of air, namely, that required for the combustion of the fuel and the blast, should be heated separately by the waste heat and waste gases of the puddling furnace.

The puddling or boiling furnace is that in which the conversion of crude into malleable iron can be effected with the greatest rapidity, on the largest scale, and at the least waste and cost. It is also the furnace in which mineral, as compared with vegetable fuel, offers the greatest advantages. Where mineral fuel cannot be obtained, it is necessary to endeavour to apply those species of fuel which exist with the utmost economy. Processes of the nature above described have therefore been adopted when the use of wood, of turf, or of the waste gases of the blast furnace have been resorted to in puddling, and with great success, under the name of gas furnaces.

In the United States, the non-flaming character of the mineral fuel in the principal coal-bearing regions of the Atlantic States, has caused the use of blast to be resorted to to produce combustion, and a sufficiently extended flame in the reverberatory puddling furnace. The whole system, as now explained, has been adopted extensively on the Continent to produce in puddling a perfect combustion of the waste gases of the blast furnace of wood, of turf, and, in some cases, of bituminous coal.

The use of fluxes in the puddling furnace offers a wide field for experiment. Hitherto, their use has been generally confined to the oxides and subsilicates of iron. The energetic re-actions of these oxides and subsilicates on the carbon of the crude iron, when brought in contact in a melted state has given rise to the term boiling, but the silicates act also as fluxes by entering into fusion with and carrying off as slags after oxidation, the greater part of the alloyed metals and other impurities contained in the crude iron. The employment in addition of fluxes composed essentially of common salt and oxide of manganese, has been successful in this country in the refining of crude iron in the puddling furnace, to a degree which has permitted the malleable iron obtained from any of the ordinary classes of minerals to be used for conversion into steel of good quality. Fluxes of this nature are employed in foreign works wherever the production of natural steel has been effected in the puddling furnace. This has been accomplished not only with pig-iron smelted with charcoal from the manganesiferous carbonates of iron in Germany and in France, but also in Belgium, at the Seraing works, from pig-iron smelted with coke from the ordinary minerals of that district.

Grey pig-iron smelted from a large class of ores with coke possesses so much fluidity, and retains the carbon with which it is combined with so much tenacity, as to create a great element of difficulty in treating it in the puddling furnace. In reducing crude iron of this class to the malleable state, by employing the intermediate process of the coke refinery, great loss from oxidation is incurred. From these causes it is commonly sought to obtain white pig-iron from the blast furnace, and this species of crude iron (notwithstanding the inferiority in quality of the wrought-iron which results from it) is that which is generally employed for its production.

To obviate this difficulty, and to avoid these disadvantages, it appears desirable to introduce between the blast furnace and the puddling furnace some intermediate process, which, like that of the mazéage practised on the Continent, shall sufficiently decarburise the grey pig-iron,

(which is always produced most advantageously in the blast furnace), at a small cost in fuel and labour, and without entailing the enormous waste of the coke refinery, so as to enable it to be treated rapidly and without difficulty in the puddling furnace.

The great objection to the coke refinery is this, namely, that the decarburation of the crude iron, and the elimination of the oxidable alloys which it contains, cannot be effected in it without extensive oxidation of the iron itself, nor without separation and loss of this oxide, as silicate, in combination both with the silica formed during the operation and accidentally present, and with the silicates of the fuel.

To fulfil the proper requisites, the process adopted for decarburation ought to be such as to enable it to be effected without this excessive oxidation of the crude iron; the oxide formed ought to be reduced again; and the silica and silicates present ought to be removed as fusible earthy slags by the introduction of lime.

It appears that this decarburation might be advantageously effected by a very simple and convenient process, in which perfect control could be exercised over the extent to which the operation was carried; namely, in a blast furnace of the nature of the common re-melting cupola used for re-melting pig-iron in foundries. By re-melting grey pig-iron in a furnace of this nature, either alone or along with minerals containing nearly pure oxides of iron, the decarburation of the metal would be readily accomplished, the oxides melted with it would be reduced to the metallic state, while the silicates of the fuel, with the silica, alumina, and other easily oxidable alloys eliminated from the crude iron, would be separated in the form of fusible earthy slags.

The iron decarburised in a blast furnace of this description should be charged in its melted state into the common boiling furnace. By such a combination of the two classes of furnace, the conversion of crude iron would undoubtedly be effected with more economy of fuel, reduced loss of iron, together with greater rapidity and regularity in the operation.

It appears probable that some saving in fuel, accompanied by greater regularity in action, and less liability to produce oxidation, would be attained by similar modifications in the application of blast to the re-heating or balling furnace as those already recommended with respect to the puddling furnace.

The limits of the present paper will not permit any examination of the mechanical operations employed in the preparation of iron. This branch of the subject must, therefore, be dismissed with a few general remarks, notwithstanding its great importance, and the diversity of the questions involved.

The quality of malleable iron depends on the mechanical operations to which it is subjected in its manufacture, equally with the chemical processes by which it is elaborated. The nature of these mechanical operations determines not only the cleanness, soundness, and finish of this metal, but also those conditions of form by which its adaptability to the various requirements of the arts is affected.

The principal mechanical agents in these operations are the hammer and the rolls. It is only by a proper combination of both of these agents, that all the requisite qualities in well-manufactured iron can be obtained. In this country latterly there has been a tendency to supersede the use of the hammer by that of the rolls in effecting every class of operations in this manufacture. This is practicable in the production of small sizes of iron, in which the bulk is small, as compared with the immense mechanical power under command, but it is not practicable with iron of large sizes, in which soundness is requisite. Soundness in rails, large bars, plates, and thick sheet iron, cannot be obtained without the use of the hammer; nevertheless, its use is almost discarded for these purposes in this country.

In the Exposition at Paris during the past year, the iron-producing countries most largely represented in that branch of metallurgy were France, Belgium, Prussia, and Great Britain, and, to smaller extent, in proportion to the character of their industry, Sweden and Austria.

To render exhibitions of metallurgical products complete, they ought to comprise the minerals in their raw state, the fuel, the products in each stage of manufacture, the residual matters, and the metal in its finished state. The specimens in this state ought to display the quality of the article, to illustrate processes of manufacture, and to show its fitness for the various purposes for which it is applied. The selling price at the place of manufacture of the article exhibited ought in all cases to be affixed to it.

The expositions of the iron industry in the French, Prussian, and Belgian departments, were in many cases complete in these respects, with the exception of the element of price. The British department was extremely incomplete. Even the feature of price, in which, if not in quality, a degree of superiority might have been established, was entirely neglected.

The French department did not fully represent the iron-producing industry of that country. The principal exhibitors were Boigues, Rambourg and Co., of Fourchambault; the Company of the Loire and the Ardêche at La Voulte; the Company of the Aveyron at Decazeville; Dupont and Co., of Ars-sur-Moselle; Jackson, Petin, and Co., of Vierzon and Rive de Gier; the Company of Audincourt (for charcoal iron); the Company of Montataire; the Company of Denain and Anzin; and Schneider and Co., of Creuzot.

The chief features of the expositions presented by these companies were, the general possession of machinery of a very powerful class, the perfection of the mechanical operations as evinced by the soundness and finish of the specimens shown, and the high quality of the iron itself. Another striking feature among these expositions was the position which the manufacture of steel is taking in foreign metallurgy, not as an exceptional product, but as one of the numerous conditions in which iron can be applied to the arts.

The attention now paid abroad to the possession of machinery capable of working iron in the largest masses with facility, and the engineering skill applied to perfecting this machinery, was, among other evidence, shown in the French department by the rolling mill, fulfilling the important desideratum of rolling heavy iron in two contrary directions without reversing the machinery, with its connected travelling carriages, designed by M. Cabrol, the director of the Decazeville ironworks, working drawings of which were shown.

The quality of French boiler-plates was well shown by the remarkable specimens of forging out of the plate, of flanges and other connexions required for tubular and locomotive boilers, without the least fracture in the metal, and without necessity for rivetting in any case. The dimensions of the boiler-plates and heavy sheet iron were at least equal to those in the English department. The double-T iron exhibited was up to twelve inches in vertical section, and the angle iron to seven inches on each flange. Locomotive wheel-tyres, rolled without welding, were exhibited both in the French and Prussian departments.

The Belgian department contained numerous specimens of well-finished boiler-plate and sheet iron of large dimensions, from the works of Couillet, Grivegnée, Ougrée, Schlessin, Seraing, and many others. The most remarkable expositions in this department were, however, those of sheet-iron shown by Remacle and Co., of Lauheid, and by Delloye and Co., of Huy; and of steel resulting from the refining of puddled steel, shown by J. Cockerill and Co., of Seraing. Both of these latter expositions were well worthy the attention of British manufacturers.

The Westphalian and Rhine provinces of Prussia were well represented by Jacobi, Haniel, and Huyssen, of Ruhrort; by the Company of the Phœnix, of Eschweiler; by Boing, Rhör, and Co., of Limburg-sur-Lenne;

by the Company of Dillingen, near Sarrelouis; by the Company of Hörde; by the Royal Foundry of Lohe, near Siegen; and especially in their important steel industry by Krupp and Co., of Essen. There were numerous other exposants from Prussia in this department, some of them from Silesia. The above expositions were, however, those containing the most important objects. The boiler plates and sheet iron shown by Jacobi, Haniel, and Huyssen, were very well finished; one plate was the largest and heaviest exhibited. Its dimensions were 24 feet by 5 feet, sheared. Its weight was 2,500 lbs. The Phœnix Company, of Eschweiler, displayed the heaviest rolled bar. This bar was 10½ inches diameter by 23 feet 6 inches long. It weighed 3¼ tons. These specimens were remarkable as evidences of the character of the machinery now erecting at continental works. The expositions of these two houses presented numerous other examples of their manufacture, and complete series of the ores, fuel, fluxes, and products in the various stage of progress; the whole were also arranged in such manner as to enable them to be closely inspected. These features of completeness and good arrangement were prominent throughout the whole of the Prussian metallurgical department. In this point of view Great Britain presented a very unfavourable contrast.

The remarkable exposition of Krupp and Co., of Essen, in Westphalia, showed the wide range of purposes to which cast steel may be applied with advantage. This house exhibited rolls of large size, axles, piston-rods, cranked shafts, and other objects, up to the weight of about 5 tons in this material, proving its applicability to those purposes in which an extreme degree of strength and durability, combined with lightness, are required. Krupp and Co. are said to use the newly-invented puddled steel largely in the production of their cast steel.

The iron industry of Great Britain was neither adequately nor advantageously represented at the Paris Exposition. The display possessed in no respect the features required to place this great manufacture in a prominent point of view.

A large number of the ironworks of this country did not exhibit, and the specimens displayed by the others were not classified in any manner, either with reference to their nature, or the locality of their production. The position also in which they were exposed prevented access, for the purpose of examination, to any other than a few of the more bulky objects. The numerous smaller specimens were so placed, that it was impossible to approach them near enough to inspect them properly.

The quality of the iron exhibited was not shown in any conclusive or advantageous manner, nor were there any specimens displayed proving the application of greater or even of equal mechanical power in the working of iron in this country as compared with others.

So far as quality in the iron exhibited was concerned, there can be no doubt that great superiority was manifested at Paris by other countries as compared with Great Britain; and unfortunately there was no attempt made to place prominently in view that point in this great industry in which we are, at present, unquestionably without rivals, namely, the cost of production. By an unaccountable omission, there were no prices affixed to any of the specimens of iron exhibited in the British department.

In concluding the present subject, the following reflections appear to present themselves. Great Britain does not possess the resources of vegetable fuel, the use of which in some processes of the iron manufacture produces such valuable results in the quality of the metal so treated; and when its partial employment can be combined with that of mineral fuel, in those other processes in which the latter can be most advantageously applied, enables the best quality of this metal to be obtained coincidently with cheap production; but Great Britain possesses almost inexhaustible supplies of mineral fuel, and of iron ores, (for the most part of good quality) in immediate contiguity to each other, and these advantages are less generally possessed by other countries engaged in this industry.

Perhaps the very abundance of the mineral resources which support the iron industry of Great Britain have contributed to produce, somewhat extensively, a slovenly system of manufacture. It is at least certain, that in this country an inferior quality of iron, badly smelted, wastefully converted, and carelessly manufactured, is often produced when a superior quality might be obtained at no higher cost than that which is inferior.

It appears desirable, therefore, with reference to our future success in this department of industry, to recognise clearly, that we have no exclusive monopoly of the sources of production, and that the progress of material civilisation is facilitating the means of transport, and removing the natural difficulties interposed to this manufacture in other countries, while their industrial energies are receiving, constantly, rapid development.

It appears, therefore, highly important that we should prepare ourselves by every means for the industrial rivalry which awaits us; and the question arises, whether, in this country, we neglect any available means for this purpose? There can be no doubt that the industrial energies of foreign countries are directed, generally, by very accurate scientific knowledge, and in no department in a higher degree than in the manufacture of iron. It can only be by the diffusion of this scientific knowledge more completely than has hitherto been the case among our industrial population, and by its combination with that energy and practical knowledge which have hitherto directed them, that we can expect to maintain our present position as the chief manufacturing country in the world.

DISCUSSION.*

The CHAIRMAN said, that though they could not well enter on the discussion in full until the remaining portion of the paper was before them, yet there were so many gentlemen present capable of making valuable observations, and imparting much knowledge on the subject, whom they did not often see, that if they had any observations to make he should be happy to hear them. Though they had not the whole subject before them, yet there were many parts upon which observations might be made, without touching upon the other portions. He observed present Mr. Fairbairn, whose valuable reports on the strength of iron were well known; and he having been one of the Jurors at the Paris Exhibition, also possessed great knowledge of the iron manufactures of the Continent. If Mr. Fairbairn wished, then, to address the meeting, he should be happy to hear him.

Mr. W. FAIRBAIRN, F.R.S., regretted that he was not present at the commencement of the paper. It certainly was of great interest, and contained a large amount of valuable information as regarded the sources of supply of iron from the various countries of Europe and America, which could only have been brought together by great research and labour. He found from the paper that the production of pig iron in this country amounted to 3,000,000 tons, whilst France produced 750,000 tons. He did not exactly catch the amount produced in Prussia, Austria, Belgium, and other countries, but he understood their amount was increasing. They knew that France alone now produced 750,000 tons, and he believed that their manufactures of iron were now becoming very important. He knew that they were making rapid strides in that branch of industry, and that their manufactures were very superior to what they were ten years since. He would not say they were as yet equal either in quantity or quality to those of England, but it behoved the English manufacturers to see that they did not get behind in the quality as well as the quantity produced. It was evident from the paper that

* It will be observed that the report of the discussion on both sections of Mr. Blackwell's paper is here given.

the subjects on which it treated had been very carefully selected, and the meeting was greatly indebted to the author for the clear and instructive form in which he had investigated the geological formations of the different kinds of ores. It must appear obvious, from these researches, that we possessed in Scotland and elsewhere immense amounts of black-band, from which excellent iron was produced. He believed that the great fault of our iron was owing to the introduction of the hot blast for its manufacture. Sixty years ago, before the hot blast was introduced, not more than forty tons a week was produced. Now, since the use of coal in the manufacture of iron by the hot blast, great advantages had been conferred upon the country by the largely increased quantity of iron produced. He doubted, however, whether the quality and strength had not been greatly deteriorated, as regarded its resistance to strain and its powers of elasticity, but in other respects he thought the hot blast valuable for many purposes, and that was proved by experiments made by himself and Professor Hodgkinson some years ago. Still he was convinced that they could manufacture as good iron as ever they did, were they to return to the old process of washing the ore and coking the coal, as the material, the fuel, and the flux were the same as formerly. It appeared also by the paper, that in France there was a large quantity of the mineral in reserve, and that there were not less than 650,000 square acres of coal in that country. How much of that was workable he was not prepared to say, but it evidently must have a very marked effect upon the manufactures of that country. The author had as yet only shown them the sources from which the iron was to be obtained, but he had not come to explain the improvements and cheapening which had taken place in its production. When he came to that portion of the subject he (Mr. Fairbairn) should be glad to make a few further remarks, if he had the opportunity of attending the meeting. He would only say at present that he was satisfied other countries were making great progress in the manufacture of iron, and unless this country also made great progress, their productions would shortly be as good as those of England.

Dr. Percy, F.R.S., would reserve his general observations until he had heard the remaining portion of Mr. Blackwell's valuable paper, as he thought it was anticipating the subject to enter into a discussion at present. He believed the hot blast would produce as good iron as was ever manufactured, if, as Mr. Fairbairn stated, good ore, good fuel, and good flux were employed. In Staffordshire, he used to see in a single heap 20,000 tons of tap-cinder. But as this tap-cinder contained in a concentrated form certain impurities of the ore, such as phosphorus, it was evident that in introducing that cinder into the furnace, the smelter virtually introduced impure ore. Phosphoric acid he had found existing in some varieties of tap-cinder in Staffordshire to the extent of 6 per cent. The extensive consumption of this cinder might, therefore, be one cause of deterioration in the quality of the iron now made. He believed that England possessed as good ore, as good fuel, and as good fluxes as ever, and if engineers would give the proper price for it, there would be no difficulty in producing iron of as good quality as before the introduction of the hot blast.

Mr. Warrington Smyth, F.R.S., was a little disappointed on entering the room to find that iron manufactures were not to be entered on that evening, but at the same time Mr. Blackwell had evidently so carefully treated his subject, that they could not object to his having a further time for the completion of his paper on that portion of it. He (Mr. Smyth) had lately had an opportunity, as a British juror, of examining the admirable collection of specimens in the French Exhibition, illustrative of the smelting and manufacture of iron. He, however, was disappointed at seeing the incomplete display of British manufacture, more especially in articles of size. Prussia, like France, had greatly improved, both in the quality and quantity of her iron manufactures, within the last few years, and he was astonished at the size of the manufactured articles from those countries and from Belgium, showing the existence there of large and powerful machinery. The English department was meagre. Though the collection, so far as it went, was admirable, it was so small that it could give no idea of the real extent of our iron manufacture. France showed water-pipes of six feet diameter, but England had none there—and he was informed that in the supply of cast-iron water-pipes for Madrid, the French manufacturers had been enabled successfully to compete with the English. Then, with regard to our wrought iron, there was very little shown, excepting some remarkably good girders. There could be no doubt that both France and Prussia were making great progress in their iron manufactures, and would become powerful rivals with England if she did not go on advancing in a still greater ratio. The Exhibition of 1851 drew the attention of Prussia to the black-band, and had led to the discovery of that ore there, and he believed that there were now forty furnaces in Prussia engaged in the production of iron from that source. A few days ago, he had seen some sword blades, not made at Birmingham, but which had been imported from Prussia, at a cost of 4½d. each. He did not say that he should like to see them placed in the hands of our soldiers in the Crimea. They were meant for Central Africa, where the best quality was not required. He was of opinion that the British manufacturers would have to contend against a very serious competition, if they did not progress in a greater ratio than at present.

Mr. Bird would reserve his remarks until another opportunity, when he would be prepared to join issue with Mr. Smyth on the poverty of the Iron Exhibits at the Paris Exhibition. As regards the paper just delivered, it was geologically and geographically a most excellent introduction to the subject, and he anticipated much information from the next meeting. That Mr. Fairbairn, after testing hot blast iron so completely, and finding it so nearly of a strength with cold blast, should recommend a return to cold blast, and a consequent large reduction of make, appeared singular, but the benefits arising from the cheapening of iron by hot blast, Mr. Bird was also prepared to defend if necessary. Large pipes were not an object that would have been at all interesting or necessary at the Paris Exhibition. Very large pipes up to 6ft. were made in this country, it was well-known, but English iron-masters and founders disliked to exhibit what would be considered a *tour de force*, but for usefulness and to supply a healthy demand for any required quantity, no country displayed a better assortment of all qualities than Great Britain.

Mr. Fairbairn wished to explain, lest he should not be present at the next meeting, that he did not mean to condemn the hot blast iron. In some cases it possessed great advantages, and from its ductility was peculiarly adapted for light machinery. But where great strain or tension was required, he could not in any case recommend it. He looked upon it as valuable, however, in consequence of its utility and adaptation for general purposes. He did not say it was the hot blast that injured the iron, but the use of raw ore and coal, introduced phosphorus, sulphur, and other substances into the iron, which injured its quality. With respect to the manufacture, he believed if they were to calcine the ore, and coke the fuel, they would have quite as good iron as formerly, and be enabled to compete successfully with all the world. He was anxious to see their iron manufactures before all others. They had got the lead, and they ought to keep it.

The Chairman thought they were much obliged to Mr. Fairbairn for his observations, although he believed the valuable experiments of that gentleman showed they could get as good iron made by the hot as by cold blast.

Mr. Joseph Freeman thanked Mr. Blackwell for his highly instructive and valuable paper. He should be sorry to allow anything to go forth which might have any tendency to frighten the iron masters, without saying a

few words. If anything important was wanted by parties abroad, they came to England for it. Look at our castings of tons weight, which were manufactured for exportation. With reference to hot blast, the most conclusive argument he had heard against it was, that during the hot summer months the quality of pigs was inferior to that produced during the cold weather—a proof that cold blast iron was better than hot. He believed the paucity of the show of English iron at the French Exhibition arose from the manufacturers being so fully employed that they could not spare time to prepare specimens. He would be sorry to believe that they were behind the age in their iron manufactures. In 1851 they were told that they were behind the Americans in the manufacture of pistols, but he believed that opinion had been controverted, and that England manufactured far better small arms than any other country. They were also told that all their locks could be picked, but he understood that those who asserted it had gone back to America fully convinced that as good locks could be manufactured in this country as in any other.

Mr. R. F. DAVIS would not be led by the eminent examples which had preceded him, to enter upon the manufacturing portion of the subject, which was not before the meeting, but would confine himself to the geological portion, which had been brought before them in so able a manner; to pass unheeded the geological question and to then enter upon the manufacturing question, was indeed putting the cart before the horse. He could not though avoid remarking, that one great practical man (Mr. Fairbairn) was in error, when he said as good iron was not to be had now as formerly. He begged to say as good iron was to be had if people would pay the sufficient price for it. The fault of the age was, all running after Cheap John, low price, regardless of quality, but as good iron was made now as ever was produced. Reverting to the admirable paper read that evening, and for which their best thanks were due to the learned and talented author, he could not avoid congratulating the iron masters of this country, that those great visions of American overwhelming capabilities of making iron which had been brought before them last year, were, when calmly considered and brought to their fair proportions, nothing so very formidable. The excellent paper they had heard read had brought very vividly before them the great resources for iron making possessed by many countries in Europe and in America, yet it was consolatory to know that, taking into account the natural facilities which existed in this country, by the close proximity to each other of ironstone, coal, and limestone, their excellent quality for all manufacturing purposes, and the advantages of climate, to say nothing of skilled labour and ready means of conveyance, no country named by the author of the paper was likely successfully to compete with our own. He would beg though to call attention, and especially the attention of the able author of the paper before them, to other places than those named by him, which might, in time, prove formidable rivals to this country. He would allude to India, where large fields of iron ore and coal existed. Again, Borneo possessed large, and they might be valuable, fields of iron ores. Australia, too, was rich in iron ores, although, he believed, none had been found there in proximity to coal. Turkey in Europe, and Turkey in Asia too, were lands possessing the mineral more especially under their notice, in great abundance, and, he trusted, that the attention of the author of the paper before them would be drawn to all these countries—it would be most interesting and valuable to have as full information on them as we had now, thanks to the zeal and intelligence of Mr. Blackwell on other countries.

Dr. PERCY had listened with delight to Mr. Bird's observations after Mr. Smyth's doleful remarks. Iron was not their only manufacture, surely; copper was nearly, if not equally as important, and yet he was informed that not one house of any repute in Swansea exhibited. He was glad to find from Mr. Bird's remarks that they need have no real anxiety as to the continuance of their own trade.

Mr. BIRD wished to ask Mr. Blackwell whether he was not wrong in stating that the sparry carbonate had been smelted *alone* in this country, and whether it did not make a steel, or cold short quality of iron, and not a red short quality, as stated in the paper.

Mr. BLACKWELL said that the spathose carbonate had been smelted in this country alone, and he believed that, when so smelted, it had produced red short iron. In the Wear valley, the ores were of the same character as the Styrian. Although, as in Styria, the upper parts of the lodes were often changed into hydrated peroxides, they generally consisted of pure carbonates. He regretted that his paper had extended to a greater length than he had originally intended. With their permission he would withhold any remarks on the debate until its close.

On resuming the discussion on the second evening,

Mr. BIRD said he was sorry that there was no one present who appeared desirous of making any remarks before he spoke on the valuable paper before them. The quarterly meeting of ironmasters at Birmingham was held that day, and that no doubt tended to keep many gentlemen from the meeting who would otherwise have been present. However gratified he had been with the geographical and geological portion of the paper, he could not help feeling that the author had been somewhat discursive with regard to the manufacturing portion, and that the difference of manufacture in different countries had been somewhat lost sight of. He also thought that the paper should have entered somewhat into the commercial part of the subject, for that had been almost entirely lost sight of, though the article of iron was one in which the manufacture annually amounted to 6,000,000 tons. He thought that the author, having for his object to show them the present condition of the iron trade of Great Britain with reference to other countries, ought to have shown them whether geologically they were worse or better situated than others, whether their mode of manufacture was worse or better, and whether they were advancing or retrograding in their commerce. As regarded the manufacturing position, the country produced 3,000,000 tons, or half the entire quantity made in the world. Exporting one-half, or $1\frac{1}{2}$ millions of tons, which would require 10,000 voyages of ships of 150 to 200 tons to transport away annually, and the internal transport annually over their railways was more than 3,000,000 tons of iron alone. Indeed it was scarcely possible to estimate how great was the benefit conferred upon the railways by the traffic in connection with the iron trade and its necessary wants. Was it to be supposed that so large a quantity could find customers in all parts of the world, and that quality was not appreciated as well as cheapness. A demand embracing 3,000,000 tons must, of necessity, embrace every conceivable quality, and the great value of this industry was, that in England every quality was produced. He thought the author ought to have entered more into that subject. Indeed, it was hardly just to the producers of iron not to show that England gave the cheapest article, whilst its iron was the best suited for the general requirements of the trade.

The CHAIRMAN stated that Mr. Blackwell had gone very fully into the geographical, geological, and chemical parts of the question; and had he entered fully on the manufacturing and commercial parts, he must have occupied two evenings more.

Mr. BIRD was referring to the title of the paper, which surely embraced those points. With regard to the manufacture of iron, he might observe that the paper did not say one word about the brown clay and lignite of Austria.

Mr. BLACKWELL—That was in the last paper.

Mr. BIRD—Not a word as to the mode in which they were used. There was also the peat and gas-manufactured iron, of considerable interest.

Mr. BLACKWELL had done his best considering the limits of his paper.

Mr. Bird would say a few words, then, with regard to foreign countries, who, they were told, were following close upon our heels in the iron manufacture. Why Prussia, in 1854, manufactured less than 250,000 tons. He believed it did not exceed 215,000 tons, and surely it could not be said such a country was treading closely on the heels of one where 3,000,000 tons were annually produced. Now, with regard to the progress made by this country, in reference to that of others, we found that in 1845 France manufactured 510,000, whilst she now produced 750,000 tons annually, showing an advance of not quite 250,000 tons in two years, whilst in nine years the manufacture in this country had increased from 1,500,000 to 3,000,000 tons. He thought, therefore, the English manufacturers had no reason to be afraid of the competition, and that the energy and industry of our own country had not received perfect justice at the hands of Mr. Blackwell. He did not wish to say much about the Paris Exhibition. It should not be condemned, as it had been by the author, for it must have some redeeming points. He would say a few words on the subject, because this paper would go forth to the world with the authority of Mr. Blackwell's name. He stated, "to render exhibitions of metallurgical products complete, they ought to comprise the minerals in their raw state, the fuel, the products in each stage of manufacture, the residual matters, and the metal in its finished state." It never was intended that the Paris Exhibition should embrace these matters. It was an exhibition of the Iron Trade, and ought not to combine the fuel, the ore, and the fluxes. No one who came to him to purchase iron rails or other descriptions, ever said, "Let me see your ores and your fluxes." They must also recollect that in the limited space allotted to them it would have been impossible to have such an exhibition, especially when showing the productions of 70 exhibitors. The make of pig iron in Scotland exceeded 820,000 tons per annum—an amount greater than the whole manufacture of France, or of the combined manufactures of Austria, Prussia and Sweden; yet one square yard of space would have been sufficient to illustrate that manufacture of 820,000 tons; all that was actually required being four pigs, marked, respectively, Nos. 1, 2, 3 and 4, thus showing the whole of the qualities manufactured. Though there were, possibly, three tons, from different makers, in the Exhibition, still the four specimens he had mentioned would have been sufficient to show to Frenchmen and other foreigners the qualities of Scottish iron. There was no part of the exhibition of English iron which did not appear to him to have been, as far as possible, properly arranged as to locality. There was the pig and bar iron of Scotland, the bars and pigs from Yorkshire and Wales, and the iron of Staffordshire and Derbyshire, all systematically classified. Then, it was said, there was no price affixed to the iron. It was true each article was not priced, but on each stand the prices were given in conspicuous figures, as showing the approximate value of the iron of that description; the Scotch hot blast iron being marked at from 75s. to 80s. per ton, and superior qualities £6 to £7. It was the same with the bar and the sheet iron; and, moreover, reference was made to an office close by where any information could be readily obtained. He had told them what might have been done for Scotland in a yard square; the same might be said of the products of the Ebbw Vale Company, and Messrs. Guest and Co., who confined themselves almost to one department of manufacture for sale. The manufacturers of France made and showed pig iron, malleable iron, chain cables, tin plates, wire, &c., so that each manufacturer could make a taking display in the exhibition. He was not there to eulogise or apologise for the difference of the English system, but only to show what it was. The Ebbw Vale Company exhibited some sections of rails of excellent quality, as did also Guest and Co. Yet, notwithstanding the Ebbw Vale Company were manufacturing 2,000 tons per week, the nature of their products did not require many yards square to exhibit. The Dowlais Company, Ebbw Vale Company, and Messrs. Bairds, he believed, were manufacturing fully 250,000 tons a year together, and yet, though these makers manufactured nearly as much as Prussia, all they made could have been well represented in a few yards square. Though the articles shown by the English exhibitors were consequently confined to a limited space, yet there were several objects which, to practical men, were of the greatest interest. In the first instance, the English department showed, without exception, the finest specimen of rolled iron. Mr. Blackwell alluded to the rolled bar of the Eschweiler Company, of 10¼ inches diameter. That bar was shown in conjunction with the section of the pile from which it was manufactured, a pile packed round the size of the bar. Any one knew that a pile so packed would produce a bar by once passing through the roll, but a bar of any diameter, so produced, was not equal to Messrs. Bagnall's bar of 7¼ inches produced from a pile which was packed square, and had probably gone through the roll thirty times. The next object of interest to which he would allude, were the taper bars and ship's knees exhibited by the Mersey Company, of Liverpool. Their process was to roll a piece of iron, which might be four inches in thickness at one end, with the assistance of hydraulic power, so that it should gradually taper off, and, probably, not exceed one inch in thickness at the other. Then there was the English "Barlow" rail, as exhibited by the Rhymney Company, it being well-known that the French had never been able to succeed in making Barlow's patent rails, even to their own satisfaction. England had also in the Exhibition the heaviest and largest rails. There was, moreover, a wrought iron 9-pounder cannon, which had never been looked at by the jury or tried. He believed it was the only one in the Exhibition. It was beautifully finished, and had been turned out of hand by Messrs. John and Edward Walker, of Gospel Oak. The English had in the Exhibition every description of bar-iron, from the lowest at £7 10s. per ton, to bars at £14 per ton. He felt that there were many shortcomings on the part of his countrymen in the Exhibition, but he could not conceive that the iron trade of Paris could, from their display, come to the conclusion that England was "the poorest country in the world" in the iron trade. He had not spoken either of the plates of the Shelton Company, of Staffordshire, or the Derwent Company, which were of excellent quality and texture—or many other matters, but he had occupied the time of the meeting already too long, and begged to thank them for the attention given to him.

Mr. Anderson (Inspector of Machinery, Royal Arsenal, Woolwich) said, that while he felt greatly interested in the very valuable paper which had been read on the important subject of iron, he took a very different view of the question from Mr. Bird, who, along with the great majority of those engaged in the iron trade of this country, seemed to make quantity rather than quality the great consideration. He believed that, as a nation, we thought a great deal more of the gold than of the quality of the material which we produced, and that, instead of improving in quality as we ought to do, we were in reality descending, and were actually making worse iron as a whole than we were 50 years ago. In the position which he (Mr. Anderson) occupied, where the quality of iron was the chief object, and from having ample opportunity of knowing how little was done to improve the quality of our material, not only by the ironmasters who make it, but also by the engineers who use it, he felt at no loss for the cause of this most lamentable condition, that while there were a few who had made and do make systematic experiments, the great majority do not, hence the quality was degenerating year by year, until at length it had become celebrated for its cheapness and inferiority all over the world. In 1854 he went to the United States of America, and, on arriving in Boston, visited the foundry of Mr. Alger, and was much struck with the rigid system of testing to which the iron was subjected, not occasionally for the sake of experiments, to be published merely,

but daily, for Mr. Alger's own information, for the express purpose of improving the strength and elasticity of his castings; and these experiments were conducted in a careful manner, with every particular recorded. As a natural consequence, they had raised the quality in an extraordinary degree, its strength being equal to 40,000 lbs. per square inch, which was nearly four times the strength of some Scotch iron. In other large foundries which he visited a similar system was prevalent, and the same kind of testing apparatus was employed, more particularly at the celebrated works at West Point, in the State of New York, and at the establishment of Major Wade, at Pittsburg. In their foundries, Scotch iron was largely employed chiefly for its cheapness, but when strength was an object they employed other iron, mostly Pennsylvanian, or from Nova Scotia. Having occasion to visit the Continent a few months ago, he found them all eager after a superior quality, while the question of cheapness was secondary. In the foundry at Liege a constant series of experiments are carried on, in regard to the tenacity, compressibility, elasticity, transverse strength, (by driving a steel plug into a conical socket,) and other similar experiments, which are all entered in a properly tabulated book, along with a complete statement of the mixtures, the fuel, the flux, state of the blast, atmosphere, and other conditions. The result of such a course could not fail to improve the iron, and all concerned, in regard to its manufacture. In the new foundry at Spandau, they even went farther than this, for, in addition to these mechanical tests, they had a complete laboratory alongside the workshops, where careful analyses of the metal were constantly being made. They had also an immense hydrostatic balance, for taking the specific gravity of the castings. By these several means they were enabled to know precisely the condition of the metal which they employed. How unfavourably this system contrasted with the general practice in our country, where the great aim seemed to be to make money. Such a state of matters was deeply to be deplored by all who had the prosperity of this country at heart, and unless our engineers, as a body, commenced a similar system of testing the iron which they purchased, and insisted upon a certain amount of strength and elasticity, he feared that the present tendency to inferiority and cheapness would ultimately injure the iron trade of the kingdom.

Mr. KENNARD, though agreeing in the principles laid down by Mr. Anderson, was bound to say that commercially he could not follow them. Men in trade must look at the means by which they would best protect their own interests and develope their business. He quite agreed with Mr. Anderson that it was desirable to improve the quality of their iron, but he thought Mr. Bird's remarks had shown that those states were commercially the most prosperous where the quantity and quality of iron produced were found in the long run the most useful. The whole system of English manufacture was rather to develope the quantity than the quality, though both were important. He observed that purchasers never thought so much of quality as of cheapness, and those houses which had done best, were those who could supply the largest amount of iron which would stand the test required for ordinary purposes. It was true that in the Exhibition of 1851, in the cutlery department, there were shown surgical instruments, &c., which, for finish and workmanship surpassed our own—indeed, with which England could not compete. No doubt in this respect there could be no comparison between the manufactures of England and those of France and Prussia; but, as a nation, England had the greatest amount of useful productions. As long as the present system prevailed there would be a desire to manufacture for cheapness rather than quality. In looking back at the history of the iron masters of the country he found that those were placed in the happiest position who had gone for the quantity produced; and, with the profoundest respect for the opinions of Mr. Anderson, he thought that the iron masters, under the pressure placed upon them by the consumers, were justified in going for quantity rather than quality, though he would be glad if he could see both combined.

Mr. R. F. DAVIS thought the especial thanks of the Society were due to Mr. Blackwell for his valuable paper, but it was also deeply indebted to Mr. Bird for his observations. The author of the paper had gone well into the geographical and geological part of the subject, and he had got the manufacturing part up to boiling point, but no further. He thought it was a pity the boiling point had not been treated more briefly, or that the subject had been delayed to a later period in the session, when they could have heard something more of the manufacturing and commercial part of the question. He was sorry the paper had not more closely pointed out the difference between the articles exhibited by Great Britain and by other countries, as it was not at all difficult to produce the *tours de force* shown by their neighbours in the Exposition. Mr. Anderson differed much from the rest of his countrymen, in being more fond of glory than of siller, and he did not think many of the Scotch ironmasters would agree with him. Mr. Anderson had spoken of the attention paid by the Americans to quality, but there was not a man in the trade who did not know that the American customer never said a word about quality, but always about cheapness. It was not goodness but cheapness they looked to, and therefore they bought large quantities of Scotch pig-iron, though they would prefer buying the bar at the price of pig. If he were asked the question, he should be compelled to say, there never was an ironmaster who went for honour and glory, but always for profit. If the Yankees did not go for dollars in America, as they came across the salt water they certainly lost or changed their character. He (Mr. Davis) could have wished that in the geographical portion of the paper, more had been said relative to Turkey in Europe, Turkey in Asia, Australia and India. In the latter countries were most important mineral fields, which might be brought into competition with England, but they need not fear anything that could be done in Europe, notwithstanding all they had heard about France and Prussia. The agricultural interest, it used to be stated a few years since, only flourished because it was protected, but now protection was gone it was stronger than ever. The iron trade of France existed because it was protected, but if they would take off the duty, the English would in their own markets, in the words of Jonathan, eat them off the face of the earth, and bring about for themselves a more healthy trade. He thought Turkey in Europe and in Asia worthy of attention, because, with returning peace, there would be a rush of English capital into those countries, where it would find a good field for its exercise. There was also India and Australia, that second England across the waters, worthy of great attention. There were on the table some specimens of iron and iron ore from Australia, which, though they might yet be regarded as only *tours de force*, were worthy of attention, as evidences of what might be expected from a country where they had whole hills of ore. He (Mr. Davis) trusted upon some future occasion Mr. Blackwell would tell them something more about the manufacture of iron, and also turn his attention to the commercial part of the question.

Mr. BLACKWELL said the hour was so late that he should only reply very briefly to the remarks made by some of the preceding speakers. Mr. Bird had said that the paper now concluded was incomplete. He had not ventured on any criticism of the practical part of the paper, but had asserted that no notice was taken of the use of lignite and turf abroad, nor of the possible use of the latter in the iron manufacture in Ireland. He was wrong in this statement. These subjects had been spoken of in their proper place, and if Mr. Bird had listened to that part of the paper read to-night, he would have found that the means adopted abroad for utilising these species

of fuel in the puddling and re-heating furnace had been fully explained. Mr. Bird had evidently been guided in his remarks by his own narrow view of the nature of this paper. He had looked at the subject in a commercial point of view only, as an iron-merchant, and not as an iron-master. The subjects discussed in the paper did not interest Mr. Bird; perhaps he (Mr. Blackwell) might be permitted to express the opinion that Mr. Bird was not qualified to judge of this paper, but that the subjects discussed would be regarded with some interest by the iron-masters of this country. The main features of the paper were—first, a general view of the resources of this and other countries for the production of iron; secondly, an examination of the principles involved in the various processes of its manufacture; and, lastly, a short account of the state of this industry in other countries as shown by the Paris Exposition. Far from under-valuing the element of cheapness in production, he (Mr. Blackwell) thought that an examination of this paper would show that the main question throughout was. whether the existing processes of the iron manufacture were of such a nature as to permit their amelioration in any respect, so as to enable iron to be produced with more economy of material, and, therefore, at a lower price than it now is. Mr. Bird's remarks were, some of them, of a rather ambiguous nature. The space for the British Iron Exposition was too restricted to permit it to be made complete; but one foot square was all that was required for a full exhibition of the products of the Scotch iron trade. It was most profitable to make cheap inferior iron, without reference to the possibility of the improvement of the present processes, without entailing extra cost; and the fact of the products of the Lowmoor Iron Company finding their way into France, was cited to prove that the English system of making cheap inferior iron was the best, commercially. The continental houses who exhibited any specimen of large size, showed nothing but a *tour de force*, but the fact was not mentioned that access to the British Exposition was obstructed by masses of rails 80 feet long, which prevented any examination of the quality of the smaller specimens of iron. In conclusion, he (Mr. Blackwell) hoped that Mr. Bird would complete his review of the iron industry by a paper on its present commercial position and movements, which no man was more competent to touch with ability and correctness.

Mr. BIRD might mention, with regard to charcoal iron, that in Austria it was found that castings were much improved by the admixture of Scotch pig iron with the charcoal pig. It was well known also that a good strong iron might be obtained by the admixture of four or five qualities, each of which might in itself be tender. He might also be allowed to tell Mr. Anderson that the beautiful iron castings of Berlin, consisting of trinkets, bracelets, &c., were principally made from Scotch pig iron, without chemically testing it.

On the motion of the CHAIRMAN, a vote of thanks was given to Mr. Blackwell for his valuable paper.

The Secretary announced that the Paper to be read at the meeting of Wednesday next, the 16th instant, was " On Tonnage Registration," by Mr. C. Atherton, M. Inst. C.E. On this evening Capt. J. M. Laws, R.N., will preside.

The SECRETARY has received the following letter on the subject of Mr. Blackwell's paper, and the discussion upon it:—

SIR,—The very able paper of Mr. Blackwell on our iron industry called forth remarks in the discussion rather of passion than of the philosophy which distinguished Mr. Blackwell's paper. The object of Mr. Blackwell was to show that it might be a very practicable thing to produce good iron at the same cost as inferior, and that the knowledge requisite to attain this object was very well worth seeking after; and hints thrown out to this effect were readily and usefully echoed by Colonel Wilmot. But the gentlemen who can see nothing in any kind of work save its reducibility to immediate pecuniary profit, and who probably would be ready to work up all the raw material of England in one week, to throw it into the sea the next, for the sake of a per centage on the transaction—on the one hand; and the gentlemen on the other, who set up perfection in manufacture as the only fitting object for worship, have simply given us another version of the contest of the black and white shield.

In truth, good and bad are relative qualities—meaning, superior and inferior; but, *quoad* what? We need ductile iron for wire, and rigid iron for pillars and girders; and it would be better in all cases to supply their places with steel, if it could be had with the same amount of human labour. A very perfect rail could be made of the material of a watch main-spring, but it would be a very aristocratic luxury to have the mass of railways unmade, in order to apply the capital in a special line of superior rails to Windsor or Brighton. I cannot agree with those who scoff at our iron industry, because fortunes are made by supplying a cheap material for common purposes, and I think the fortune-maker a very useful member of the community, for helping to turn stone roads into iron ones, even though of inferior iron. It may not be the highest kind of taste to think an agency in the accumulation of money capital is the most worthy of all objects, but the men who pursue this fulfil a part in creation at the command of Providence, as surely as a Liebig, or a Faraday, a Bacon, a Newton, or a Shakspeare; and the Americans are not more imbued than ourselves with the spirit of reverence for artistic perfection in work. England truly supplies a want which the world feels and expresses for cheap iron, and while the demand shall continue for low-priced iron—the only iron the masses can afford to pay for yet—she will continue to supply the want. As the masses grow richer they will need better iron, and the stimulus given England will produce that better iron in larger amounts, cheapening it as she best may under the pressure of competition. The coal, the ironstone, the climate, and the people, are gathered together in a favourable locality for work on the large scale; and in that work which it is the instinct of the Anglo-Saxon to perform diligently, which he has never yet shirked, and probably never will; they will continue to excel in the iron trade till the coal and iron shall be exhausted. That they prefer a hundred church-clocks to one chronometer, or a fleet of iron ships to a pleasure-barge, should not be an imputation on them. They do that which other nations do not; and if the common iron they now make by millions of tons, points the way to a demand for an equal amount of better iron, that also they will be ready for.

Notwithstanding, we must not lose sight of a truth embodied in the outcry of those who advocate the sacrifice of profit to excellence of production. The mere money-hunters may go on competing with each other to the point where utility is sacrificed and profits disappear in the contest to produce rubbish. Nothing is more certain than that the originator of new things is the best friend to the manufacturer. He gives him a fresh vantage ground whereon to regenerate a losing trade. It is the constant tendency of manufactures to cheapen. In proportion as a process becomes common and certain, profits lessen; and it is a frequent remark, that if business were as easy to do and as certain as the funds, it would only produce the same annual interest. A sprinkling of enthusiasts amongst our guilds of workmen as well as masters is a gain to the community. Some years back, an English traveller wished to possess himself of a pair of miniature boots exhibited in the window of a *cordonnier* in one of the Parisian *passages*. No inducement could make the man dispose of them. " You can make another pair," said the traveller. " Never!" shouted the master, striking

his breast as only a Frenchman can; "they were made in a moment of enthusiasm." Laugh as we may, it was this spirit that captured the Malakoff, and it is this spirit, gradually growing more rife in England, which will prevent manufacturers from falling into the pit of unprofitable money-grubbing. Artists and inventors will scheme to

"Ring out the old ring in the new!"

as their appointed time comes round, and the manufacturer,—the industrial chief who rules files of workmen,—will become more and more aware that the mind of the philosopher is an element that he can no more dispense with than he can with his capital.

I do not believe that the labour of Mr. Blackwell will be thrown away. His words will produce fruit in the silent mode in which such things take place in England. Even now many teeming brains are stirring with thoughts of the future, and when the custom-houses of Dover and Calais shall be let for warehouses, and the huge ship of Scott Russell shall be a channel ferry, moving incessantly across the "narrow sea" to its alternate landing-stages, between stone moles on either coast, then will the marvels of international rivalry spring up in all their glory, in which the mutual superiority of both nations in divers things will continually strengthen their mutual interest.

I am, sir, yours faithfully,
W. BRIDGES ADAMS.

1, Adam-street, Adelphi, Jan. 9, 1856.

RATING OF INSTITUTIONS.

The Working Men's Educational Union recently appealed against a poor-rate made upon the premises occupied by that Society. The case came on for argument in the Court of Queen's Bench, and on the 23rd November last Lord Campbell delivered the following judgment. The particulars of the case sufficiently appear in the judgment, as taken from the short-hand writer's notes, of which a copy is subjoined:—

Lord CAMPBELL said,—The question to be decided in this case is, whether the Working Men's Educational Union, as described in the Second Annual Report of that Society, is a society "instituted for the purposes of science, literature, or the fine arts, exclusively," within the meaning of the statute, the 6th and 7th Victoria, chapter 36, so that a house in the parish of St. Martin-in-the-Fields, occupied by the Society for the transaction of its business, is exempted from rateability for the relief of the poor? This is a most laudable society, the members disinterestedly devoting themselves to the improvement of their fellow-creatures; and if the principle were to be acted upon by the legislature that laudable societies should be encouraged, by increasing the burdens of the ratepayers of the parish in which the house of business appears to be situated, although the object of this Society be not of a parochial nature, this Society will have a right to the exemption now claimed. But hitherto exemption has been confined to societies instituted for purposes of science, literature, or the fine arts, exclusively; and looking to this Society as described in its Second Annual Report, we do not think that it comes within the statutable definition. It uses science, literature, and the fine arts as part of the means for gaining its objects, but its direct objects are not the cultivation or promotion of science, literature, or the fine arts; and some of the purposes for which it was established and instituted cannot be connected with science, literature, or the fine arts. The report states, "that the Working Men's Educational Union was founded in the year 1852, having for its objects the support of the efforts variously put forth for the elevation of the adult operative population, as it regarded their physical, intellectual, moral, and religious condition." The words of the first fundamental law are:—"That this Society be designated the Working Men's Educational Union," having for its objects the elevation of the working-classes, as regards their physical, intellectual, moral, and religious condition. The means are, by encouraging popular literary and scientific lectures—by preparing suitable diagrams and other aids to lecturers—and by promoting the formation of popular lending libraries and mutual instruction classes. There is a provision that the publications issued or recognised by the Society shall be free from party politics of the day, and shall be scriptural and unsectarian in their character, but there is no other qualification upon the express objects and purposes of the Society. Now it is clear that any lecture would come within the scope of this Institution which may fairly be considered as leading to the elevation of the working-classes as regards their physical condition; such as lectures teaching them how their lodgings, clothing, and food may be improved, whereby their physical condition may be elevated. It follows that the funds of the Society may be properly applied to the preparation of diagrams explaining how cottages may be better built, ventilated, and cleaned; how the garments of the labourer may be better made and mended; and how his food may be more economically cooked, or rendered more nutritious. Reviewing the very multifarious subjects discussed by the lecturers, as stated in the report, the physical condition of the working-classes does not appear to have been so much attended to as might have been expected, although we have one lecture on "Total Abstinence from Alcohol;" but to promote their intellectual improvement we find many discussions, all perfectly salutary and elevating, but several of them showing that they have no connexion with science, literature, or the fine arts,—for example, "Ought we to ask for the Ballot?" "The Voluntary Principle or an Establishment, which?" Although diagrams of a balloting-box, of a cathedral, or of a dissenting meeting-house may be called in aid by way of illustration, surely it was not meant by the legislature to exempt from rateability to the maintenance of the poor the houses in which instruction upon such subjects is communicated by the lecturers, or in which they are discussed after the manner of a debating club. We should have placed no reliance upon such a discussion in a provincial affiliated society, unrecognised by the parent Society in London, but the second report of the parent Society recognises and approves of the discussion of such subjects by the affiliated society, which are to be encouraged by suitable diagrams and other aids to the lecturers. "This course," says the report, "is justified upon the grounds that political subjects will be discussed elsewhere, generally in the pot-house, and that it must be desirable that such discussions should take place where moderation can bè enjoined, and partizanship abated, and the information afforded likely to direct to right conclusions, while, at the same time, freedom of debate is secured, and opinion allowed unfettered expression." In considering these cases, the Courts have had to ascertain the purposes for which the Society is instituted, and would not only look to its written laws, but to the purposes to which the funds of the Society have been practically applied. We do not yield to the objection made at the bar, that Mr. Scott had a beneficial occupation of the house, as we believe that it was used for the purposes and objects of the Society, and for no other purpose whatever; nor to the objection that the subscribers had a benefit, from being allowed to buy diagrams at a reduced price, as *profit* was *not* the legitimate object of the subscription, and they could not buy diagrams to sell again without being guilty of abuse. Nor was the objection much relied upon by Mr. Pashley, that some religious and biblical subjects are lectured on, such as "The Bible, its Origin, &c.," "The Spread of the Gospel of Christ," "The History of the Greek Church," "St. Peter's Chair, or the Popes of Rome," for there is a sacred literature as well as a profane, and all these subjects may be treated as part of sacred literature, without engaging in controversial theology. But as both by the laws and usages of the Society, some of the purposes for which it

was instituted appear clearly to us to be different from those of science, literature, and the fine arts, we must, upon this ground, decide in favour of the respondents. Had the founders of this Society had in view the purposes mentioned in the statute, and no other direct purpose, we should not have thought that they were disentitled because the purposes being served they had in view consequentially the object of elevating the condition of the working classes. In the Queen *v.* Jones (8th Queen's Bench), Lords Denman and Patteson, Williams and Wightman, Justices, all express a strong opinion that a society instituted for the diffusion of religious principles and sentiments, though by literary means, is not within the exemption. So in the Queen *v.* Pocock (8th Queen's Bench), it was expressly held that a society instituted for the purposes of education was not entitled to the exemption, although the object was to be gained by scientific and literary means. Williams, Justice, there said, "We find that algebra, trigonometry, elocution and poetry, are to be taught; these certainly come within the terms *science* and *literature*, but that does not show that the society was instituted exclusively for those purposes." In the present case there is a part of the object and a part of the means to be employed wholly unconnected with science, literature, and the fine arts. In the case of the Linnæan Society, supposed at the bar to be in favour of the appellant, that Society was admitted to be instituted exclusively for *scientific purposes*, and the main objection urged to the exemption was, that the subscriptions were not voluntary. According to the Queen *v.* Cockburn, and various other authorities, this society, however meritorious its objects, is not entitled to the claim it has set up, and we can feel no regret in being obliged to arrive at this conclusion, for, if the exemption were allowed, the ratepayers in the particular locality would be taxed for the support of an Institution from which they derived no local benefits. Where a fund, such as the poor's rate, is to be raised by taxing the inhabitants of a defined district, Parliament, with all its omnipotence, cannot relieve some of those inhabitants from payment without increasing the burden of the others. We, therefore, give judgment for the respondents, with costs.

Home Correspondence.

ALLIGATOR AMBERGRIS.

Sir,—In Mr. R. Temple's admirable letter, dated from Belize, British Honduras, and which appeared in the *Journal of the Society of Arts* on Jan. 4th, he speaks of an odorous substance which the alligator throws off, resembling, as he says, musk. I am inclined to believe that the material is more likely to be found to resemble ambergris; however, if he will send some of it to England, I shall be very happy to test its value as an odorous body, in a perfumery sense, and if it really be of the value he anticipates I can at once offer him a market for it. The present price of grain musk is about, say, 70s. per ounce, and that of ambergris 16s. per ounce, the latter being scarce in England at present. I quote the above prices in order that Mr. Temple may form an idea of the value of a substitute for musk or ambergris.

Yours faithfully,
SEPTIMUS PIESSE,
Of the firm, Piesse and Lubin, Perfumery Factors,
2, New Bond Street.

January 7th, 1856.

THE RESINS OF COMMERCE.

Sir,—I was at the meeting of your Society on Wednesday last, when Mr. P. L. Simmonds read his paper on the "Gums and Resins of Commerce," and I have, since its publication, gone through it with considerable care.

The public will, I am sure, be much obliged to Mr. Simmonds for bringing this subject under its notice, for it is one on which (I speak more particularly of the resins) very little is known, and on which a large number of individuals are very deeply interested; and in submitting it to the consideration of the members of your Society, I trust Mr. Simmonds has taken a course calculated to elicit some valuable information respecting the matters of which his paper treats.

Having little acquaintance with the Gums of Commerce, I will pass over that part of Mr. Simmonds's paper, and come at once to the Resins, on which I have a few remarks to make; and I trust Mr. Simmonds will excuse me doing so, as they will be made more with a desire to elicit information, than for the purpose of criticising the paper now under consideration. Mr. Simmonds says, that the resins 'are either natural exudations or are obtained from some vegetable compounds by the aid of alcohol." I am acquainted with many of the resins of commerce of the first sort, but not of the second; there may be such resins, but I think, commercially, they are unknown; and further, "they (the resins) have no smell except when they retain a portion of volatile oil;" from this it would be inferred that those resins which have no smell contain no volatile oil; but this, I apprehend, is not the case, for many of the resins of commerce, copal and anime, for instance, and others used by the varnish-maker, have no smell when cold, and yet they contain large quantities of volatile oil, which the application of a very little heat disengages from them.

I observe it stated that resins are used for varnishes and other purposes, and also for ornamental *house-papering*. I do not know exactly the use indicated here, but, probably, it is meant that resins are the component part of the varnishes used for varnishing paper-hangings.

In looking through the paper, I find, under the head Copal, and in other parts, that this resin copal is the product of large trees in the East Indies, is found in Palestine, Abyssinia, Africa, New Zealand, Brazils, the Phillipines, Singapore, Madagascar, South Africa, the interior of South America. It appears, therefore, that copal comes from three-quarters of the world, as well as New Zealand. Now, I do not mean to say that the term copal, as applied to the resins of those different countries, is an improper one, because I believe, as Mr. Simmonds states, that in South America the word Copalli is the generic term for all resins, but I take leave to doubt whether the copal of commerce of this country would not be found to be a very different article to the resins produced in any part of the East Indies or New Zealand. I think it will be found that the East Indian copals here mentioned are not copals, but dammar of some sort, which, although, imported and entered as copals, are sold on their arrival by the merchants here as dammar.

The copal of commerce, a resin used principally, I believe, by the varnish-makers, is a product of Africa. It comes to England direct, the sort most prized and the oldest known being the Sierra Leone copal. Other varieties of resins have lately come into the market. They are called copals, and are the product of the Western Coast of Africa, and come direct, in most cases, from there to us. Accra, Angola, Benguela copal, are the names under which they appear in the London price current.

It is not probable that the products of this, the Western Coast of Africa, would find their way to the East Indies, but the case is different as regards the other side. The resinous products of the Eastern Coast of Africa, amongst which would be found the best sorts of anime, and a resin commercially called East India copal, are most probably collected by the Indian merchants, carried by them into Indian ports, and from thence shipped to this country. The resins so obtained are, however, African productions, and not Indian; they are generally good in quality, and fit for the oil varnish-maker. It is a fact that the resins best adapted for this class of manufactures are almost all tropical productions.

I am not aware of the commercial distinction, which Mr. Simmonds makes, of the copals into hard and soft.

The "copal proper," which Mr. Simmonds says all comes from India, whatever its primary source may be, and the "East Indian copal from Calcutta, the most common commercial variety, and in which pieces of all other sorts of copal are to be found," are, no doubt, different sorts of dammar. The copal from New Zealand is the resin known here under the name of Cowrie, Cowdie, or Kauri.

In referring to my collections of specimens of resins containing insects, Mr. Simmonds says, they occur in amber, the Courbaril resin of South America, copal, anime, and in copal from Accra. I wish to observe here that I have never seen an insect in the Sierra Leone copal of Africa, although I have had tons of it through my hands; this is singular, and worthy of inquiry. In anime they appear most abundant.

I have to apologise for troubling you with these remarks, but I am anxious for information, and trust that Mr. Simmonds's paper will lead to inquiry, and that we may receive from some of your readers accounts of the resins of Africa. It would be very desirable to know their origin, age, and mode of collection. I am told that the tropical Resins of Africa are true fossils, but I have been unable to learn whether this is the fact or not.

I am, your obedient servant,

THOMAS H. WALLIS.

64, Long Acre, Dec. 4, 1855.

THE ASSAM SILK WORM IN THE WEST INDIES.

SIR,—By the first November mail last year, through the kind attention of his Excellency Sir William Reid, Governor of Malta, I received a supply of the Assam silk-worm, which feeds on the castor oil plant, *ricinus communis*. Thirty cocoons had been placed in a bamboo bird-cage, at Malta, and during their voyage hither *via* Southampton, the moths came forth, and deposited about 1,200 eggs, which on their arrival had begun to hatch. These I soon distributed by twenties and fifties to all who chose to try the experiment, which perfectly succeeded as far as relates to their being adapted to this climate, and to their propagation rapidly and perfecting the cocoons. This is abundantly proved from the fact that this day (being twelvemonths from their introduction) I have the eighth generation of worms now hatching, having had seven crops of cocoons within the year.

These worms multiply one hundred-fold in each generation, and there is no doubt of their being easily fed to any amount, provided that their product can be sold in the European market in the state in which it is when the moth comes out from the cocoons, of which I enclose you a sample.

As the castor oil tree grows very rapidly, and can be cultivated without much expense, and yields a good return in its very abundant seeds, it is admitted by most persons that the employment of persons in raising silk could be advantageously adopted if the product can be turned to good amount. The object of my letter is to solicit information on this head, say,—

1st, Whether cocoons, such as those enclosed, can be sold in England, and at what price.

2ndly. Whether they can be rendered saleable by any treatment, and if so, by what description of treatment can they be made marketable.

3rdly. What description of machinery is used for rendering Assam silk fit for manufacturing purposes, and what is the cost of such machinery or such portion as would be required to prepare the cocoons previously to shipment.

4thly. What is the value of the castor oil *beans* in London, Liverpool, or elsewhere.

I shall feel obliged by information on these and any other points tending to elucidate the problem of the profitable raising of silk in these islands.

I would not have your readers to infer that the castor oil silk-worm can be raised in the open air; on the contrary, they must be kept in the shade, and carefully protected from various enemies that abound in these climates, as ants (which are a pest), lizards (innumerable), and jack spaniards, or wasps, (which appear to take a malignant pleasure in destroying the delicate creatures by stinging them to death); from their whiteness they also attract many birds, and domestic fowls feed on them with avidity. It may be, that from their rapid powers of multiplication, they may yet be established in the open air upon a large scale, when we shall have planted large fields of the castor oil; at present all our open-air experiments have been made with small quantities on single trees, and therefore this point cannot be cleared up until after we know whether the silk cocoon be of any value.

I shall be glad also to learn (further than I see in Dr. Ure's Dictionary) something as to the manufacture of silk-worm-fishing-gut; all my trials failed of producing a *strong* line. Of what strength should the vinegar be? How long must the worms be kept in it? At what particular stage of maturity must the worm be put into the vinegar?

I hope you will not consider this deficient in that sort of interest which will confer a place in your columns, and I shall anxiously look for some notice of my queries, which, if answered favourably, will, I doubt not, lead to very important results.

I have seen with regret that at Malta the experiment has failed, through the unfavourableness of the climate.

I have had the pleasure of forwarding these worms to Tobago, Trinidad, St. Vincent, Dominica, and Martinique; they were sent to the latter place by request of its governor. All are anxious to learn whether the silk can be sold in your markets, and all are convinced that any quantity can be cheaply raised as soon as they are satisfied that it will be worth while.

I am, Sir,
Yours very truly,
JOHN WELLS.

Mount Pleasant, Grenada, West Indies,
November 23, 1855.

MEETINGS FOR THE ENSUING WEEK.

MON. London Inst., 7, Dr. John Tyndall, "On the Nature and Phenomena of Heat."
Architects, 8, Mr. C. H. Smith, "Remarks on the Forms, Methods of Casting, and Ringing of Large Bells, with some suggestions on the subject."
Geographical, 8½, 1, Lieut. Maury, U.S. Navy, "Notice on the Proceedings of the U.S. ship-of-war *Vincennes* to the North of Behring's Strait;" 2, Dr. E. K. Kane's "Report to the Secretary of the United States Navy, on his search for Sir John Franklin, during the years 1852-53-54, accompanied by a Chart showing the Discoveries made during the course of that Expedition; 3, "Note on the further progress of Dr. Vogel in Central Africa."

TUES. Civil Engineers, 8, Mr. J. M. Heppel, "On the relative proportions of the top, bottom, and middle webs of Girders and Tubes."
Linnæan, 8.
Pathological, 8.

WED. Society of Arts, 8, Mr. Charles Atherton, M. Inst. C.E., "On Tonnage Registration."
Ethnological, 8½.

THURS. Antiquaries, 8.
Royal, 8½.

FRI. Asiatic, 2.
London Inst., 3, Mr. T. A. Malone, "On the Elementary Principles of Animal and Vegetable Chemistry."
Medical, 8.

PATENT LAW AMENDMENT ACT, 1852.

APPLICATIONS FOR PATENTS AND PROTECTION ALLOWED.

[*From Gazette January 4th*, 1856.]

Dated 26th November, 1855.

2656. Denis Jonquet, 63, Mina-road, Old Kent-road—Improvements in the blades of mechanical cutting machines, and in the

blades of single or double-handled cutting instruments, and in the blades of ordinary and mechanical shears and scissors, and in the handles and springs for the same.

Dated 28th November, 1855.

2683. Charles Jean Baptiste Barbier, Paris—Improved kiln for burning or firing pottery, bricks, tiles, and other earthenware.
2685. Benjamin Rosenberg, New Charles-street, City-road—Improvements in protecting metallic and other surfaces from corrosion and decay. (A communication.)
2687. Richard Archibald Brooman, 166, Fleet-street—Improvements in the manufacture of sand, emery, and glass papers, and in the machinery employed therein. (A communication.)
2689. Samuel Wolff, Independence, Jackson County, Missouri, U.S.—Improvements in obtaining motive power.
2691. Charles Clarke, Farm-lane, Walham-green, Fulham—Improvements in applying roughings to the feet of horses.

Dated 29th November, 1855.

2693. Thomas Symons, Flushing, Cornwall—Improvements in the permanent ways of railways, and in the wheels rolling thereon.
2697. Alfred Vincent Newton, 66, Chancery-lane—Improved process of manufacturing hats. (A communication.)
2699. Pierre Louis Bergeon, Paris—Improved spitting-box or spittoon. (A communication.)

Dated 30th November, 1855.

2701. Henry Thomas Humphreys and James Loughry, Kilmacow Mills, Waterford—Improvements in machinery or apparatus for cleaning wheat.
2703. Auguste Dusautoy, Boulevart des Italiens, Paris—New and useful machinery for cutting cloth and other substances.
2705. Edward John Davis, 64, West Smithfield—Improvements in preparing food for horses and other animals.

Dated 1st December, 1855.

2707. Edmund Alfred Pontifex, Shoe-lane—Improvements in furnaces.
2709. William Needham and James Kite (Secundus), Vauxhall—Improvements in machinery or apparatus for expressing liquids or moisture from substances.
2713. William Augustus Woodley, Taunton—Improvements in the manufacture of paper bags.

Dated 3rd December, 1855.

2715. David Anderson, Strandtown-house, Down, Ireland—Improvements in machinery or apparatus for the preparation or manufacture of felt and other fibrous materials.
2719. William Rowan, Belfast—Improvements in steam-engines.
2721. Alexander Watt, 83, Dean-street, Soho—Improvement in coating iron and steel with zinc.

Dated 4th December, 1855.

2723. Samuel Garn, Sevenhampton, Wiltshire—Improved tipping apparatus applicable to carts and other vehicles.
2727. Joseph Barling, 7, High-street, Maidstone—Improvement in the manufacture of paper by the application of a root not before used for the purpose.
2729. William Knight, St. Marylebone—Improved mode of cutting out or shaping materials to be employed in making overcoats or other similar articles of dress.

Dated 5th December, 1855.

2731. Adam Bullough, Blackburn—Improved lubricator for looms.
2733. William George Plunkett, Belvidere-place, Dublin, and John Bower, Lower Ormond Quay, Dublin—The manufacture of fibres or threads for textile fabrics and cordage, also of paper, mill-board, and other similar boards, from plants or portions of plants not hitherto used for these purposes.
2737. Cæsar Heilmann, 22½, Milk-street, Cheapside—Improvements in grates or furnaces for steam-boilers.

Dated December, 18th, 1855.

2858. Christian Rudolph Wessel, 25, Fitzroy-square, New-road, and George Bowden, Little Queen-street, High Holborn—Joining elastic webbing into indissoluble bands.
2860. John Pierrpont Humaston, Newhaven — Improvements in instruments for composing and transmitting telegraph messages.
2862. David Lloyd Price, Beaufort, Brecknock—Improvements in electric telegraphs and in appliances connected therewith as applied to railway trains and fixed stations.
2864. Hiram Hyde, Truro, Nova Scotia—Improved mode of purifying alcohol or alcoholic spirits. (A communication.)
2866. Edward Davies and John Milne Syers, Liverpool, and Charles Humfrey, Camberwell—Improvements in distilling resinous, bituminous, fatty, and oily matters, and in the treatment of certain products therefrom.
2868. Frederick Robert Augustus Glover, Bury-street, St. James—Improvements in the construction of breakwaters, sea-walls, and other structures or foundations which lie partially or entirely under water.

Dated 19th December, 1855.

2870. George Ross and Thomas Wilkes, Birmingham—Improved machinery for the manufacture of bolts, rivets, spikes, screw-blanks, screws, nuts for screws, and washers.
2872. John, Henry, Frederick John, and Charles Staunton Hadden, Nottingham—Improvements in circular frames for the manufacture of ribbed fabrics.
2874. Henry Robert Abraham, 11, Howard-street, Strand—Improvements in carriages, and in certain appurtenances and appendages which belong to those used as hospital conveyances or ambulances.

Dated 20th December, 1855.

2876. Robert Walker, Eccleston, near Prescott—Improvements in applying power to and in machinery for raising and lowering coals and other articles from and into mines.
2878. Andrew Shanks, 6, Robert-street, Adelphi—Improvements in instruments for indicating pressures.
2882. George Tomlinson Bousfield, Sussex-place, Loughborough-road, Brixton—Improvements in machinery for splitting leather. (A communication,)
2884. John Barcroft, Hanley, Stafford—Improvement in the materials to be used in the manufacture of baskets and basket-work.
2886. Louis Rudolph Bodmer, 2, Thavies-inn—Improvements in hydraulic seed-crushing machines or oil-presses.

Dated 21st December, 1855.

2888. Jean Baptiste Emile Saffroy, Bordeaux—Improved break for railway carriages. (A communication.)
2890. Thomas Edward Merritt, Maidstone—Improvements in breech-loading ordnance and fire-arms.
2892. Matthew Tomlinson, Ivy-house, Culcheth, Lancaster—Improved medical plaister.
2894. James Murdoch, 7, Staple-inn—Improvements in machines or apparatus for working chain-stitch embroidery. (A communication.)
2896. Henry Francis, 456, West Strand—Improvements in apparatus for cutting out parts of garments.
2898. William Joseph Curtis, 1, Sebbon-street, Islington—Improvements in fog signals, and in laying the same upon the rails of railways.

WEEKLY LIST OF PATENTS SEALED.

Sealed January 4th, 1856.

1500. George Guillaume.
1501. Georges Antoine Tabourin.
1534. Henry Crosley.
1547. James Hall Nalder.
1624. Robert Martin and John Cowdery Martin.
1680. Richard Archibald Brooman.
1682. Thomas Hewitt.
2060. James Higgin.
2492. Richard Threlfall and John Higson.
2546. John Henry Johnson.

January 8th.

1536. John and Anton Bruno Seithen.
1537. François Loret-Vermeersch.
1541. Richard Archibald Brooman.
1553. Julius Jeffreys.
1554. John Adams.
1556. William Williams.
1567. Charles Byrne.
1574. Eugène Gillet.
1583. Louis Constant Joseph Poliesse, junr., and Charles Auguste Joseph Lengelée.
1593. Jean Baptiste Piscal.
1595. James Newman and William Whittle.
1616. John Ellis.
1621. Auguste Edouard Loradoux Bellford.
1626. Samuel Barlow Wright and Henry Thomas Green.
1649. Peter Armand le Comte de Fontaine-Moreau.
1655. Samuel John Pittar.
1705. William Mardon.
1831. Lewis Normandy.
1963. William Gossage.
2089. Lewis Dunbar Brodie Gordon.
2129. Joseph Beattie.
2135. Alfred Vincent Newton.
2158. Josias Nottidge.
2168. James Good.
2175. Joseph Beattie.
2220. Edward Meldrum and James Young.
2247. William Edward Newton.
2337. Doctor Graham.
2347. Henry Giller.
2381. John Edwin Mayall.
2390. Joseph Robinson.
2405. Edwin Tomlinson and Alfred Mortimer Job.
2443. Robert Kerr.
2479. William Henly Walenn.

PATENTS ON WHICH THE THIRD YEAR'S STAMP DUTY HAS BEEN PAID.

December 27th.

19. George Gwynne and George Fergusson Wilson.

December 28th.

1186. John Copling, junior.
1192. Archibald Douglas Brown.
11. John Bleackley, junr.

December 29th.

21. Jean Baptiste Pascal.

December 31st.

41. Peter Graham.
92. William Brown.

January 1st.

39. William Edward Newton.
125. Peter Fairbairn and Samuel Renny Mathers.
189. Alfred Vincent Newton.
240. William Edward Newton.